Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

Renewable Energy Program

1985-1988

Passive Solar

Energy Efficiency and Diversity

Canada

RENEWABLE ENERGY PROJECTS DIGEST
Passive Solar

Energy, Mines and Resources Canada
580 Booth Street
Ottawa, Ontario
K1A OE4

© Minister of Supply and Services Canada 1988
Cat No 0-662-16489-X
ISBN M91-7/32-1988E

Aussi disponible en français

This report is distributed for informational purposes only and does not necessarily reflect the views of the Government of Canada nor constitute an endorsement of any commercial product or person. Neither Canada nor its ministers, officers, employees or agents makes any warranty in respect of this report or assumes any liability arising out of this report.

October 1988

RENEWABLE ENERGY PROJECTS DIGEST

1985-1988

Passive Solar

RENEWABLE ENERGY PROJECTS DIGEST

1985-1988

Passive Solar

A review of all passive solar research, development
and demonstration projects funded
by Energy Mines and Resources Canada

October 1988

90-01226/

Preface

The Renewable Energy Projects Digest - Passive Solar is part of a series of six progress reports which review and update all the current and completed renewable energy (non-bioenergy) projects funded by Energy, Mines and Resources Canada.

The renewable energy programs at EMR support research, development and demonstration projects that are environmentally safe, encourage industrial development and export opportunities, and most importantly, can yield a growing contribution to Canada's energy supply. In addition to passive solar, EMR also provides support for the development of active solar, wind energy, photovoltaics, small and low-head hydro, earth energy and bioenergy technologies in Canada.

The Renewable Energy Projects Digest - Passive Solar traces a brief historical and technical perspective of passive solar technology in Canada and contains over 40 summaries of the passive solar projects funded by EMR. A key-word index in the final pages of the document provides a directory to the distinct elements of the technology.

Companion documents to this publication include Projects Digests for Active Solar, Wind Energy, Small and Low-Head Hydro (which also includes information about tidal energy development), Photovoltaics and Earth Energy. An Overview document is also available which contains extended compilations of the Contractors Registries, key-word indexes and other information helpful to understanding EMR and its mandate. To obtain a copy of any or all of these publications, readers are invited to fill out the order form on page 61 and send it to the address provided. Like the Renewable Energy Projects Digest - Passive Solar, these publications reflect the growth of renewable energy in Canada and how it is fostered by a partnership between government and industry.

The Renewable Energy Projects Digest - Passive Solar will provide a useful compendium of current passive solar technology development in Canada. To ensure that readers are kept abreast of achievements in this field, this document will be revised each year.

Table of Contents

Page

Introduction 9

RESEARCH AND DEVELOPMENT PROJECTS

ABL Technologies Limited
- Assessment of the Need for New Controls for Solar Buildings 13
- Development of a Passive Solar Hybrid Controller 14

Acadia University
- Testing Laboratory for Low-Emissivity and Electrochromic Coatings 15

Allen Associates
- The Development of a Technology Transfer Program for Second-Generation Passive Solar Technology 16
- Heat Pumps for Enhancing Passive Solar Heating 17

Baines Wilder & Company
- Assessment and Advancement of the Marketability of High-Performance Window Technology 18

Concordia University
- Energy-Storing Wallboard 19

Diamond Structures Limited
- Performance Evaluation of the Sloped Glazing Assembly 20

E.J. Faraci and Associates Limited
- Porous Transparent Aerogels for High-Performance Windows 21
- Passive Solar Seminars: Increasing Design Awareness in the Prairie Provinces 22

Edgetech Limited
- Edge Spacers for High Thermal Performance Windows 23

Enermodal Engineering Limited
- The Effect of Frame Design on Window Heat Loss - Phase I 24
- Computer Analysis of Improved Window Frame Designs - Phase II 25
- Improvements to the Enerpass Computer Program 26

G.K. Yuill and Associates Limited
- Design and Development of a Laminar Air Flow High-Performance Window 27
- Performance Modelling Using a Calibrated Model 28

INRS-Énergie
- Electrochromic Devices for Optically Switching Windows 29
- Development of a Prototype Electrochromic Optically Switching Window 30

Insulor
- Development and Construction of a Window with an Incorporated Insulating Roller Shade 31

Memphremagog Community Technology Group
- Simplified Passive Solar Building Performance Monitoring Program 32
- Preparation of Passive Solar Home Performance Briefs 33

Ontario Research Foundation
- Energy Performance Evaluation and Labelling Requirements for Windows 34

Parinova Incorporated
- Development of Gypsum Wallboard with Phase-Change Material Thermal Storage 35

Parker Design Limited
- Development of an Evacuated High Thermal Performance Window 36

Repla Limited
- Improved Gas-Filling and Gas Retention Technology in Sealed Insulated Glass Glazing Panels 37

Secor Incorporated
- Advanced Passive Solar Technology: The Window Market in the United States and Canada 38

Simon Fraser University
- High-Performance Windows from Pyrolytic Deposition of Fluorine-Doped Tin Oxide on Glass: U-Values and Electrical Contacts 39
- Electrostatic Deposition of Tin Oxide Coatings on Glass Using an Aqueous-Charged Aerosol 40

TIR Systems Limited
- Redesign of the Solar Light Pipe for Multi-Storey Illumination 41

Tang G. Lee Architect
Development of a Theoretical Design Method for Domestic Solar Space Heating Systems 42
Unicel Incorporated
Thermal Improvement of "Vision Control" Windows 43
University of Moncton
Study of Electrochromic Materials for Switchable Windows 44
University of Saskatchewan
Monitoring and Performance Evaluation of Attached Sunspaces 45
University of Waterloo
Centre of Expertise for Basic Research into Advanced Glazing Systems 46

DEMONSTRATION PROJECTS

Allen Associates
Development of a Prototype Residential Integrated Mechanical System 49
Appropriate Technology Energy Company
Insulating Curtain for Greenhouses 50
Flair Homes
High Thermal Performance Windows in the Flair Homes Energy Demonstration Project 51
Fram Building Group
Advanced House Demonstration Project in Ontario 52
Grace Institute
Passive Solar Technology Information Sessions 53
Model Home Which Uses Passive Solar Concepts 54
Konvey Construction Company Limited
Demonstration of a Solar Light Pipe System 55
Les Constructions Solden Incorporated
Hybrid Solar Systems in Urban Housing 56
Solar Nova Scotia
Solar Greenhouse Construction Course: Instructors Seminar 57
Thermactive Incorporated
Solar Climate Control System 58

Introduction

Technology Description

Passive solar buildings optimize the solar resource available to them by collecting solar energy through their windows, directly using both the collected heat and light, and by storing excess heat gains for use later when the sun is not shining. Well designed passive solar buildings also incorporate elements to prevent overheating during peak summer months.

Passive solar technology integrates the collection, distribution and storage of energy into the design of the building itself, and is therefore inherent to good building design. Because building science varies from region to region and because the need for heating, cooling and day-lighting is strongly affected by local climate, appropriate passive design tends to be specific to a given area.

The principal advantage of passive solar is that most building components can serve a dual purpose. Because windows, for example, are both solar collectors as well as an integral part of any building, the extra cost of solar collection can be relatively small. For new houses, no extra costs are required to achieve a solar contribution to the heating load of approximately 25 per cent. The best current designs emphasize south-facing windows (about 8 to 10 per cent of the floor area) with open, direct-gain rooms behind them.

Although passive solar tends to be identified with the residential sector, reductions in the purchased energy can also be achieved in commercial buildings. Improved windows can eliminate the need for costly perimeter heating systems in high-rises, and sophisticated control strategies can distribute solar gains from the south side of all-glass office buildings to the colder northern sides. New technologies such as electrochromic coatings on windows and light pipes also have the potential to help reduce cooling and lighting energy costs in these types of buildings.

Historical Perspective

Research programs in this and other renewable energy technologies were developed following a decision by Cabinet to reduce oil consumption and incorporate alternative energy sources into national supply networks. Thus, the Interdepartmental Panel on Energy Research and Development was formed in 1975 to review and assess federal energy R&D and to develop Tasks and Programs to be managed by selected federal departments and agencies with expertise in various technical areas. The National Research Council was the federal agency with the responsibility of managing the renewable energy task and, in the 1984/85 fiscal year, was spending about $2.0 million in the field of passive solar energy. With the elimination of the NRC's Energy Division in 1985, the program mandate was taken over by Energy, Mines and Resources (EMR). To date, EMR has spent about $3.5 million over the last three years, providing the major impetus in developing passive solar technologies.

Canadian Achievements

One of the earliest Canadian ventures into passive solar technologies was the Saskatchewan Conservation House in 1977, which demonstrated all the first-generation passive solar technologies still in use today - low-energy construction, increased south-facing glazing with overhangs for summer shading to avoid overheating, and reduced north glazing.

The most significant Canadian research on passive solar technologies was carried out by the NRC's Solar Energy Program from 1978 to 1985. Initial research focused on calculating and quantifying solar gains and on qualitative performance analyses.

NRC's Passive Solar Test Facility was used for intensive Level A performance monitoring, which gathered minute-by-minute data for five years. This sophisticated facility provided the data for the International Energy Agency to validate its member countries' computer design tools. The monitoring analyses led to algorithms incorporated into HOTCAN, a microcomputer program widely used across Canada and required by EMR to determine compliance with R-2000 standards. Using these design tools to optimize solar features can lead to direct-gain houses with a 25 per cent solar contribution at almost no incremental cost, simply by relocating windows and adding overhanging eaves for shading.

During 1983-86, over 20 solar houses were subjected to a simpler Level B monitoring procedure. The results showed an average solar contribution of 28 per cent - a significant increase over the 12 per cent contribution typical for conventional housing. This research led to the rules of thumb for achieving a no-cost 20 to 25 per cent solar contribution.

* 8 to 10% of floor area in windows, oriented within 15o of south
* forced-air heating systems to distribute solar gains
* conventional building materials to provide thermal storage
* low-energy construction techniques to reduce energy loads

If only one-half of the 200,000 new houses which are expected to be built in 1988 followed these simple rules, passive solar would supply $20 million of "free" space heating in the first year, and would continue to do so every year for the service life of the houses.

NRC research also showed that across Canada, each 1 m2 of south-facing double glazing moved from the north side of a house to the south averages a 0.9 GJ net solar gain over the heating season. With energy at $14 per GJ (5 cents per kWh), this solar contribution could produce a savings of $12.50 per m2, or $125 to $250 per year for an average house.

The NRC program also funded the development of an acrylic tube with almost total internal reflection under the tradename "Solar Light Pipe". It can be used with a heliostat to provide solar lighting, or, with high-intensity light bulbs, it can be used to duct lighting into cold storage rooms or explosive atmospheres. A major demonstration funded by EMR has been carried out on a commercial office building near North York, Ontario, and research is continuing to allow the device to illuminate several floors at the same time.

International Perspective

Because Canada's climate is similar to that of northern Europe, Canadian

passive solar technology is developing along similar lines. So far, the emphasis into passive solar research and development in northern Europe, Canada and the United States has focused on four major areas:

* Sunspaces and atria
* Direct-gain systems
* Computer design tools
* Better windows

All countries have learned the lesson that passive solar strategies make most sense once heating and cooling loads have been reduced through conservation strategies. In most countries, the heaviest emphasis in research and development is now on major improvements to windows, one of the few building energy components that has not undergone a significant improvement in energy efficiency since the oil crisis in the mid-70s.

Current Programs

With an annual budget of slightly over $1.2 million for contracted-out research, development and demonstration, EMR has established priorities in basic research and product development.

The objective in passive solar R&D is two-fold: first, to research new concepts and products which will allow a greater passive solar contribution to energy loads of buildings, and second, to provide information to industry to encourage them to include passive solar features into their building designs.

The heaviest emphasis of the program is on major improvements to the energy performance of windows. A window with a thermal insulation value of RSI 1 - a 300 per cent improvement over conventional windows - has been established as a performance target because, at that level, windows collect more energy than they lose, even on the north side of buildings.

If 50 per cent of the estimated 10 million square meters of new windows installed annually in Canada were increased to RSI 1, the energy savings would be over $73 million in the first year alone. These savings would compound annually over the lifetime of the windows.

To help industry attain these savings, approximately 59 per cent of the available budget is spent in the area of high performance windows, including basic research, product development and industry support activities. In addition, about $250,000 is being spent on two demonstration projects featuring RSI 1 windows and other solar features.

Other passive solar technologies being supported include thermal storage, integrated mechanical systems and day-lighting in commercial buildings.

Because many design and construction professionals are still unaware of the full potential of existing technologies, the dissemination of technical information has become a high priority. To encourage acceptance of passive solar technologies, the program is also emphasizing public education in the form of booklets, solar house performance fact sheets, design guidelines and slide shows.

Future Directions

After 10 years of federal support for passive solar, we know that with good design and conventional low-energy building techniques, we can build houses with a 20 to 25 per cent solar contribution with no increase in capital cost. We also know that with better windows and better thermal storage, we can provide a 45 to 50 per cent solar contribution and possibly a reduction in energy to heat water.

A study to demonstrate the potential of passive solar technologies in commercial buildings is underway, and we hope to establish similar energy targets for commercial buildings.

Specifically, research priorities over the short-term include the following:

i) Develop and commercialize high-performance windows
ii) Fine-tune thermal storage strategies, including integrated mechanical systems
iii) Develop day-lighting methods for commercial buildings
iv) Support innovative passive solar concepts
v) Transfer the technologies from the research community to the designers, builders and manufacturers

PROJECT SUMMARIES
Passive Solar

Research and Development Projects

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

ASSESSMENT OF THE NEED FOR NEW CONTROLS FOR SOLAR BUILDINGS

Contractor
ABL Technologies Ltd.
205-919 Fort Street
P.O. Box 5550, Station B
Victoria, B.C.
V8R 6S4

Principal Investigator
H. Day Chapin (604) 383-1123

DSS File No.: 23216-5-7313
EMR File No.: CE7161-A1
Contract Start Date: Feb 86
Completion Date: Aug 86
Project Value: $13,500
EMR Funding: $10,125

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Although great strides have been made in other areas of passive solar design and system performance, research and development of controllers has been minimal in comparison. With the present trend toward the incorporation of various passive solar concepts into both residential and commercial buildings and the design of hybrid systems, there is a growing need for sophisticated control systems for passive solar buildings.

Objectives
To identify the requirements of the passive solar building industry with respect to automatic controllers for thermal comfort, day-lighting and thermal storage

To outline the specifications and features of advanced controllers

To determine the types of controllers currently available on the Canadian and U.S. markets and to recommend future development work in this technology

Results
A survey of the passive solar building industry indicated that less than half are satisfied with existing controls. Simple thermostats are used for lack of an adequate controller.

According to the study, a recurring problem in passive solar buildings is that users, particularly second occupants, do not operate manual controls properly. The industry survey also shows that automatic controls are preferable. The need for an integrated controller for conventional features which can also sense solar parameters was identified.

Advanced programmable microprocessor controllers could control functions such as thermal comfort, day-lighting, and thermal storage with data on the local climate, building type and occupancy. However, since this type of controlling system would be expensive to produce, it may be more feasible to concentrate research and development on a general type of controller which can manage passive solar as well as conventional features.

The study recommends the following on the basis of the survey results:

(i) development of a decision-making tool to assist in controller design and selection
(ii) information transfer in the form of courses and user guides for the controller industry and end users
(iii) development of integrated building controllers with solar options, including such features as radiant heating, heat pumps or low-flow solar domestic hot water systems

Additional Information

Final Report:
Chapin H.D., ABL Technologies Ltd. Assessment of the Need for New Controls for Solar Buildings. EMR Report No. T2-W1-85-7313. Ottawa, Ont.: Energy, Mines and Resources Canada.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

DEVELOPMENT OF A PASSIVE SOLAR HYBRID CONTROLLER

Contractor
ABL Technologies Ltd.
205-919 Fort Street
P.O. Box 5550, Station B
Victoria, B.C.
V8R 6S4

Principal Investigator
H. Day Chapin (604) 383-1123

Background
Large passive solar gains through south-facing windows may heat buildings unevenly, which sometimes creates uncomfortable living conditions. One potential solution to this problem is the use of multi-zone thermostat controls, which can provide improved heat distribution through integrated ventilation systems. Recent studies conducted by B.C. Hydro indicate that overall energy savings of 10 to 20 per cent are possible with upgraded multi-zone thermostatic controls. A previous study (see DSS File No. 23216-5-7313, "Assessment of the Need for New Controls for Solar Buildings") has identified the benefits and marketability of multi-zone hybrid controllers.

Objectives
To define the specifications for residential multi-zone thermostatic controllers

To design and construct a prototype controller and to perform a component evaluation for optimal performance and reliability

To develop a business plan for taking the controller from product development to commercialization

Results
The first milestone report presents preliminary specifications for a hybrid controller which can be used to distribute passive solar gains. Different types of analog and digital solar hybrid controllers are suggested for application in passive solar houses.

DSS File No.: 23283-7-6171/01
EMR File No.: CN7161-A2
Contract Start Date: Sep 87
Completion Date: Nov 88
Project Value: $41,600
EMR Funding: $31,225

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

TESTING LABORATORY FOR LOW-EMISSIVITY AND ELECTROCHROMIC COATINGS

Contractor
Acadia University
Department of Physics
Wolfville, Nova Scotia
B0P 1X0

Principal Investigator
Bryan Latta (902) 542-2201
Ext. 151/228

DSS File No.: 23283-7-6175/01
EMR File No.: CN7161-A3
Contract Start Date: Feb 88
Completion Date: Mar 89
Project Value: $68,379
EMR Funding: $68,379

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Among the important advancements in window technology, the development of low-emissivity (low-E) coated glazings, which offer high thermal performance by reducing radiative heat loss, is particularly significant.

Electrochromic coatings are used to control the transmission of solar energy through glazings. When electrical voltage is applied to the coating, the amount of transmission in the optical and/or infrared part of the spectrum is either reduced or increased.

As the market for these thin-film coatings grows, the need for standard and reliable measurements of their optical properties becomes more important.

A facility for the fabrication and measurements of optical properties of low-E and electrochromic coatings should be developed.

Objectives
To study solid-state thin-film electrochromic coatings by developing a facility for their fabrication and optical measurements

To perform optical analyses of electrochromic coatings and low-E thin films

To establish a test laboratory for uniform rating of the optical properties of thin films used for high-performance windows and to develop a standard method of testing

Results
Thin film fabrication equipment has been purchased by Acadia and is being assembled. Some preliminary electrochromic devices have been produced.

A computer-interfaced optical system which will replace Acadia's conventional spectrometer is nearing completion. The new system will simultaneously measure both the transmittance and the reflectance.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

DEVELOPMENT OF A TECHNOLOGY TRANSFER PROGRAM FOR SECOND-GENERATION PASSIVE SOLAR TECHNOLOGY

Contractor
Allen Associates
33 Madison Avenue
Toronto, Ontario
M5R 2S2

Principal Investigator
Greg Allen (416) 962-6193

DSS File No.: 23283-7-6208/01
EMR File No.: CN7161-A4
Contract Start Date: Oct 87
Completion Date: Oct 88
Project Value: $65,793
EMR Funding: $65,793

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
The first generation of passive solar technology focused on two main strategies to reduce the space heating loads of residential and commercial buildings. The first approach involves the use of heavy mass construction and nighttime insulation, and the second entails decreasing building envelope heat loss by means of higher insulation levels, such as those found in super-insulated buildings. However, because of insufficient information and technology transfer activities from researchers to designers, builders and other users, progress in first-generation passive solar technology has been slower than anticipated.

Recent advances in new thermal storage products, heat pump recovery systems and high thermal performance windows have led passive solar technology into its second generation. Canada is one of the leading countries in this technical development. However, designers and other users require more extensive information and training regarding first-generation passive solar technology and about recent advancements in new second-generation technology.

Objectives
To assemble an overview of second-generation passive solar technology through a review of published literature, a survey of product manufacturers and interviews with experts

To identify the technology transfer requirements for new developments in passive solar technology and to investigate existing methods of communication with the user community

To prepare an extensive technology transfer plan for Energy, Mines and Resources to communicate second-generation passive solar technology

To prepare a booklet and slide show summarizing recent developments in high-performance window technology aimed at builders, architects, engineers, specification writers and the window industry

Results
A literature survey of recent passive solar publications was carried out. The survey of manufacturers was completed and the initial information used to prepare an outline for the technology transfer program.

A technical note is being prepared summarizing high-performance window technology. In addition, a slide show on high thermal performance windows is being produced.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

HEAT PUMPS FOR ENHANCING PASSIVE SOLAR HEATING

Contractor
Allen Associates
33 Madison Avenue
Toronto, Ontario
M5R 2S2

Principal Investigator
Mario Kani (416) 962-6193

DSS File No.: 23283-7-6219/01
EMR File No.: CN7161-A5
Contract Start Date: Sep 87
Completion Date: Aug 88
Project Value: $40,695
EMR Funding: $40,695

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Recent technical improvements in high-performance glazings have generated higher net solar gains through windows. However, these advanced glazing systems require the use of integrated mechanical systems to transfer heat gains throughout the building. Heat pumps can convert solar and internal heat gains to useful space or domestic hot water requirements as well as recover heat from exhaust air or grey water.

A preliminary study by Allen Associates indicates that the proper combination and optimum design of heat pumps and integrated mechanical systems could result in system paybacks of three years or less.

Objectives
To perform computer simulations using the ENERPASS computer program and develop optimum combinations of heat pumps, ventilation systems and thermal storage units for improved passive solar performance

To develop energy-credit calculation procedures suitable for use with the HOT2000 computer software program

To establish the cost-effectiveness of heat pump systems and to prepare practical design and installation guidelines

Results
Various design combinations of heat pumps, ventilation systems and thermal storage units have been identified. These design combinations are being analyzed for their potential energy savings by using an updated version of ENERPASS. Cost-effective combinations will be selected and incorporated into designs for integrated mechanical systems.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

ASSESSMENT AND ADVANCEMENT OF THE MARKETABILITY OF HIGH-PERFORMANCE WINDOW TECHNOLOGY

Contractor
Baines Wilder & Company
1-799 Dorchester Avenue
Winnipeg, Manitoba
R3M 0P5

Principal Investigator
Bruce Fulcher (204) 477-1088

DSS File No.: 23283-7-6252/01
EMR File No.: CN7161-B1
Contract Start Date: Jan 88
Completion Date: Sep 88
Project Value: $157,510
EMR Funding: $157,510

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
The Canadian window manufacturing industry consists of about 800 to 900 manufacturers who generate approximately $1 to $1.2 billion of sales per year. The major driving force behind this industry has traditionally been the price-sensitive new construction market, and manufacturers have focused their marketing efforts accordingly. However, current window industry forecasts predict that renovations will account for almost 75 per cent of all residential sales within the next 10 years.

Although they show promise in today's window market, high thermal performance windows differ greatly from conventional windows in design and manufacture. To a small Canadian manufacturer, the commitment to produce energy-efficient windows is a critical decision that calls for substantial capital investment toward an unknown market.

This significant change in market dynamics together with dramatic technological innovations has triggered widespread concern about the industry's future direction, particularly with its capacity to compete with foreign manufacturers. A response to those changes occurred recently at a joint government and industry seminar, when a strong recommendation for a research survey to determine the market potential for energy-efficient windows in Canada was made by the window industry.

Objective
To conduct a national market survey to determine the level and nature of potential demand for high-performance windows

Results
A series of focus group meetings were held with individuals from the target groups to be surveyed, such as homeowners, builders and renovation contractors. Issues were identified and questionnaires are being developed. Window dealers be will added to the survey.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

ENERGY-STORING WALLBOARD

Contractor
Concordia University
Centre for Building Studies
1455 Maisonneuve Blvd West
Montreal, Quebec
H3G 1M8

Principal Investigator
Paul Fazio (514) 848-3210

DSS File No.: 23216-6-6090/01
EMR File No.: CN7161-C1
Contract Start Date: Jul 86
Completion Date: Jun 87
Project Value: $116,330
EMR Funding: $116,330

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Since the solar energy supply and heating demand of buildings are cyclical and not necessarily synchronous, utilization of solar energy can be improved by providing thermal storage. Incorporating phase-change materials (PCM) in wallboard is one of the most efficient storage means because of the material's capacity to absorb and release heat while changing its state from solid to liquid, and from liquid to solid, in the comfortable temperature range.

Gypsum wallboard is an appropriate container for PCM because of its wide number of applications, existing manufacturing and marketing facilities, and stored-energy distribution capabilities. However, phase-change materials which have stable physical properties, cost-effectiveness and an easy incorporation procedure must be identified.

Objectives
To select appropriate phase-change materials which are capable of storing and releasing thermal energy within a comfortable temperature range of 17°C to 23°C

To analyze physical properties and perform evaluation studies of PCM

To identify a manufacturing procedure for incorporating PCM in gypsum wallboard, to produce a prototype PCM wallboard and to perform economic feasibility studies

Results
An extensive survey of phase-change materials was conducted. Of 10 potential candidates, three were identified as the most suitable on the basis of their physical and phase-change properties.

(i) A mixture of capric and lauric acids
(ii) Butyl stearate
(iii) Propyl palmitate

PCM assimilation in gypsum wallboard was attempted by both immersion and direct incorporation techniques. The immersion process enables standard wallboard to be converted to impregnated wallboard either as a final stage in the manufacturing process or at the point of distribution. Satisfactory results were obtained by maintaining PCM temperature at 80°C for a two-minute immersion time. Prototype PCM wallboard was produced and its physical properties were examined.

Economic feasibility studies for different types of buildings show an average 30 per cent reduction in heating and cooling loads. Performance studies also indicate that the application of PCM wallboard will result in uniform room air temperature, size reduction in mechanical equipment and better thermal comfort. A patent application is pending.

Additional Information

Final Report:
Feldman, D., M. Shapiro, P. Fazio, D. Hawes and D. Banu. 1987. Energy-Storing Wallboard (Phase I): Part of the Solar Energy Development Program. EMR Report No. T2-W4-86-6090. Ottawa, Ont.: Energy, Mines and Resources Canada.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

PERFORMANCE EVALUATION OF THE SLOPED GLAZING ASSEMBLY

Contractor
Diamond Structures Ltd.
28 Bentley Avenue
Nepean, Ontario
K2E 6T8

Principal Investigator
Larry Sears (613) 226-1123

DSS File No.: 23216-6-6236/01
EMR File No.: CN7161-D1
Contract Start Date: Sep 86
Completion Date: \\
Project Value: $31,050
EMR Funding: $24,037

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Diamond Structures designed and developed the "Diamond Window Assembly", a vented double-glazing system for sunspaces featuring internal movable insulation fitted between sloped glazings. Triggered by a photoelectric cell, an automatic electrical controller lowers the insulating blanket into a knee-wall when solar gains are available and activates a blower fan to transfer heat to the house. When overheating occurs, the insulation is raised to block out further solar gains.

Six Diamond Window Assembly prototype units were installed in the field. Some of the units experienced condensation problems between glazings, particularly on north-facing installations.

Objectives
To conduct full scale tests to evaluate the condensation potential of the vented double-glazed window assembly with movable insulation

To evaluate the thermal performance of the window assembly at the National Research Council's (NRC) Window Testing Laboratory

To perform a cost-benefit analysis of residential buildings with attached sunspaces employing the Diamond Window Assembly

Results
Full scale condensation field tests were performed by Diamond Structures on a window assembly test unit during February, 1987. Preliminary results indicated that the assembly only experienced condensation if interior relative humidity rose above 60 per cent. The company concluded that their product should not be used for hot tubs or other high-humidity applications.

Because standardized thermal performance test procedures only apply to vertical glazings, the NRC tests were conducted on a prototype vertical unit. A cost-benefit analysis using a 185 m² standard reference house showed that the addition of a 22 m² Diamond Structures sunspace heated to 20°C would add 8.5 per cent to the total space heating load. Without the use of movable insulation, the sunspace would add 13 per cent to the load. If the sunspace was unheated, the solar gains would reduce the house load by six per cent.

During the course of this study, Diamond Structures went out of business. No final report is available.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

POROUS TRANSPARENT AEROGELS FOR HIGH-PERFORMANCE WINDOWS

Contractor
E.J. Faraci and Associates Ltd.
200-330 St. Mary Avenue
Winnipeg, Manitoba
R3C 3Z5

Principal Investigator
Gordon Shymko (204) 949-1000

DSS File No.: 23216-6-6257/01
EMR File No.: CN7161-E3
Contract Start Date: Mar 87
Completion Date: Oct 88
Project Value: $80,352
EMR Funding: $60,210

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
One way of increasing a window's thermal resistance is to replace the air space between glazings with a transparent insulating material. Porous transparent aerogels show good potential for this application. Composed of silica at about three per cent the density of glass, aerogel has roughly seven times the insulating capacity of an ordinary single pane of glass. Silica aerogel is also transparent to solar radiation.

In 1984-85, E.J. Faraci and Associates conducted developmental work in the preparation of various aerogel types for the National Research Council. Some of the aerogel samples exhibited excellent thermal and optical properties. A typical aerogel sample had a measured thermal resistance of 1.7 $m^2 \cdot {}^\circ C/W$ (R-9) per 25 mm thickness, with a transmissivity of approximately 85 per cent of clear glass. However, the conventional aerogel drying process employs an autoclave, which must be maintained at high temperature and pressure. Lower-cost alternative methods of manufacturing aerogels are sought.

Objectives
To investigate alternative gel solvents and drying processes for the manufacture of aerogels

To optimize a preparation procedure for making large samples of aerogels for utilization in windows and to develop prototypes

To develop and demonstrate a commercially viable process for the manufacture of porous transparent aerogel products for use in high thermal performance windows

Results
Because of the many trials in identifying a suitable preparation procedure for silica gels, progress on this project has been slower than expected. Silica aerogel samples were fabricated and their optical properties were measured. The transparency of aerogels was improved by altering the chemical composition. However, the drying process requires three to six weeks, which is substantially longer than conventional procedures.

Studies of a rapid drying process using compressed air flow are in progress and a larger aerogel sample will be produced. Alternative compositions for achieving high transmissivity are also being examined. A commercialization assessment is underway to survey the production and applications of aerogels. The contract has been extended to allow time for the aerogels to dry more thoroughly.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

PERFORMANCE EVALUATION OF THE SLOPED GLAZING ASSEMBLY

Contractor
Diamond Structures Ltd.
28 Bentley Avenue
Nepean, Ontario
K2E 6T8

Principal Investigator
Larry Sears (613) 226-1123

DSS File No.: 23216-6-6236/01
EMR File No.: CN7161-D1
Contract Start Date: Sep 86
Completion Date: \\
Project Value: $31,050
EMR Funding: $24,037

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Diamond Structures designed and developed the "Diamond Window Assembly", a vented double-glazing system for sunspaces featuring internal movable insulation fitted between sloped glazings. Triggered by a photoelectric cell, an automatic electrical controller lowers the insulating blanket into a knee-wall when solar gains are available and activates a blower fan to transfer heat to the house. When overheating occurs, the insulation is raised to block out further solar gains.

Six Diamond Window Assembly prototype units were installed in the field. Some of the units experienced condensation problems between glazings, particularly on north-facing installations.

Objectives
To conduct full scale tests to evaluate the condensation potential of the vented double-glazed window assembly with movable insulation

To evaluate the thermal performance of the window assembly at the National Research Council's (NRC) Window Testing Laboratory

To perform a cost-benefit analysis of residential buildings with attached sunspaces employing the Diamond Window Assembly

Results
Full scale condensation field tests were performed by Diamond Structures on a window assembly test unit during February, 1987. Preliminary results indicated that the assembly only experienced condensation if interior relative humidity rose above 60 per cent. The company concluded that their product should not be used for hot tubs or other high-humidity applications.

Because standardized thermal performance test procedures only apply to vertical glazings, the NRC tests were conducted on a prototype vertical unit. A cost-benefit analysis using a 185 m² standard reference house showed that the addition of a 22 m² Diamond Structures sunspace heated to 20°C would add 8.5 per cent to the total space heating load. Without the use of movable insulation, the sunspace would add 13 per cent to the load. If the sunspace was unheated, the solar gains would reduce the house load by six per cent.

During the course of this study, Diamond Structures went out of business. No final report is available.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

POROUS TRANSPARENT AEROGELS FOR HIGH-PERFORMANCE WINDOWS

Contractor
E.J. Faraci and Associates Ltd.
200-330 St. Mary Avenue
Winnipeg, Manitoba
R3C 3Z5

Principal Investigator
Gordon Shymko (204) 949-1000

DSS File No.: 23216-6-6257/01
EMR File No.: CN7161-E3
Contract Start Date: Mar 87
Completion Date: Oct 88
Project Value: $80,352
EMR Funding: $60,210

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
One way of increasing a window's thermal resistance is to replace the air space between glazings with a transparent insulating material. Porous transparent aerogels show good potential for this application. Composed of silica at about three per cent the density of glass, aerogel has roughly seven times the insulating capacity of an ordinary single pane of glass. Silica aerogel is also transparent to solar radiation.

In 1984-85, E.J. Faraci and Associates conducted developmental work in the preparation of various aero gel types for the National Research Council. Some of the aerogel samples exhibited excellent thermal and optical properties. A typical aerogel sample had a measured thermal resistance of 1.7 $m^2 \cdot {}^\circ C/W$ (R-9) per 25 mm thickness, with a transmissivity of approximately 85 per cent of clear glass. However, the conventional aerogel drying process employs an autoclave, which must be maintained at high temperature and pressure. Lower-cost alternative methods of manufacturing aerogels are sought.

Objectives
To investigate alternative gel solvents and drying processes for the manufacture of aerogels

To optimize a preparation procedure for making large samples of aerogels for utilization in windows and to develop prototypes

To develop and demonstrate a commercially viable process for the manufacture of porous transparent aerogel products for use in high thermal performance windows

Results
Because of the many trials in identifying a suitable preparation procedure for silica gels, progress on this project has been slower than expected. Silica aerogel samples were fabricated and their optical properties were measured. The transparency of aerogels was improved by altering the chemical composition. However, the drying process requires three to six weeks, which is substantially longer than conventional procedures.

Studies of a rapid drying process using compressed air flow are in progress and a larger aerogel sample will be produced. Alternative compositions for achieving high transmissivity are also being examined. A commercialization assessment is underway to survey the production and applications of aerogels. The contract has been extended to allow time for the aerogels to dry more thoroughly.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

PASSIVE SOLAR SEMINARS: INCREASING DESIGN AWARENESS IN THE PRAIRIE PROVINCES

Contractor
E.J. Faraci and Associates Ltd.
200-330 St. Mary Avenue
Winnipeg, Manitoba
R3C 3Z5

Principal Investigator
Gordon Shymko (204) 949-1000

Background
Technology transfer plays an important role in disseminating information on new developments in passive solar technology to building design professionals and the user community. The interpretation of experimental and analytical results of passive solar research into simple design methods encourages better energy-saving measures in buildings.

Upon identification of the information needs of building design professionals, seminar material on passive solar concepts will be prepared. The initial seminars will be conducted in Manitoba. If this seminar pilot series is successful, more may be held in other parts of the country.

Objectives
To evaluate the information needs of the building design community and prepare passive solar design seminars accordingly

To present seminars to building design professionals in Manitoba

Results
The preliminary survey indicated strong interest in integrating passive solar concepts into building designs. A need for a comprehensive passive solar design manual for building professionals was identified.

The project was cancelled after the completion of Phase I.

DSS File No.: 23283-7-6174/01
EMR File No.: CN7120-7
Contract Start Date: Oct 87
Completion Date: Oct 88
Project Value: $69,770
EMR Funding: $50,000

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by Office of Energy Research and Development, Energy, Mines and Resources Canada

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

EDGE SPACERS FOR HIGH THERMAL PERFORMANCE WINDOWS

Contractor
Edgetech Ltd.
39 Vaughan Street
Ottawa, Ontario
K1M 1W9

Principal Investigator
M. Glover (613) 749-0624

DSS File No.: 23216-6-6178/01SZ
EMR File No.: CN7161-T2
Contract Start Date: Sep 86
Completion Date: May 88
Project Value: $375,819
EMR Funding: $136,343

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

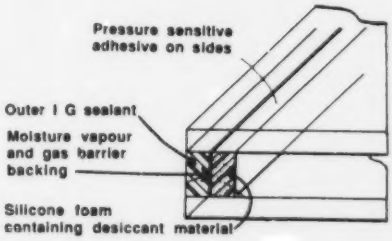
Background
Advances in high thermal performance glazing systems require similar improvements in edge spacer performance. Recent studies indicate that low-emissivity glazings combined with a low conductive gas-fill reduce heat loss by 45 per cent at the centre of the glazing. However, when the edge effects of standard metal spacers are considered, the combined overall heat loss reduction is only 33 per cent. Since conductive spacers can contribute to the overall heat loss of high-performance windows, better edge spacers of high thermal resistance are required.

A conventional sealed double-glazing unit consists of two panes of glass which are separated by a hollow metal spacer containing a desiccant which removes water vapour from entrapped air and the organic vapours from sealant materials. Recent studies show that flexible, desiccant-filled foam spacers may generate increased reliability and better thermal performance. This project was initiated to help fund the development of an innovative Canadian insulating spacer for high-performance glazing units.

Objectives
To develop and produce a silicone foam desiccant-filled edge spacer and to perform durability and performance tests and preliminary field trials

To produce flexible and semi-rigid desiccant-filled silicone foam spacers and to perform extensive field trials, structural testing and thermal performance testing

Results
An insulated edge spacer was developed and patented under the trade name "Super Spacer". The Super Spacer is made from silicone material with acrylic adhesives on both sides and foil on the back to reduce vapour migration.



Cross Section of Super Spacer

Molecular sieve desiccant material is added as a fill to the silicone foam.

A conventional edge-seal consists of four separate components: desiccant beads; hollow metal spacer; corner keys; and polyisobutylene seal. The major advantage of the Super Spacer is that it consists of all four components, simplifying the production process. The Super Spacer can also be utilized for the fabrication of specialized designs, such as curved and bent glass units.

Thermal performance tests of the Super Spacer indicate that the use of an insulated spacer can improve overall window thermal performance by up to 28 per cent compared to an aluminum metal spacer. This is a 65 per cent reduction in edge heat losses. Also, the use of the Super Spacer results in an increase of about 8°C in glass edge temperature.

Durability and performance tests have been performed at the Ontario Research Foundation. Prototype glazing units equipped with a Super Spacer have passed all required tests for the sealed glazing unit standard CGSB 12.8.

Additional Information

Final Report:
Glover, M., G. Reichert and Edgetech I.G. Ltd. Development of an Insulated Spacer. EMR Report No. T2-W4-86-6178. Ottawa, Ont.: Energy, Mines and Resources Canada.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

THE EFFECT OF FRAME DESIGN ON WINDOW HEAT LOSS - PHASE I

Contractor
Enermodal Engineering Ltd.
368 Phillip Street, Unit 2
Waterloo, Ontario
N2L 5J1

Principal Investigator
S.C. Carpenter (519) 884-6421

DSS File No.: 23216-6-6253/01
EMR File No.: CN7161-E2
Contract Start Date: Oct 86
Completion Date: Jun 87
Project Value: $50,590
EMR Funding: $45,115

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

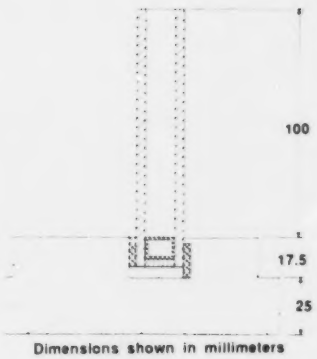
Background
Because a typical window frame comprises from 20 to 30 per cent of the total window area, the reduction of heat loss through frames has warranted attention. Analytical studies conducted at the Lund Institute in Sweden indicate that replacing a high conductive aluminum spacer with an insulated spacer could yield a five per cent decrease in overall window heat loss, a 30 per cent reduction in heat loss through the window frame alone. Studies performed by Enermodal Engineering show that for a typical house in Canada, possible energy savings of 4 to 5 GJ/yr can be achieved by improving window frame design.

Objectives
To examine the potential for improvement in window thermal resistance by improving the designs of commercially-available window frames

To develop an analytical procedure for heat transfer analysis of window frames

Results
A two-dimensional, steady-state, finite-difference computer program entitled "FRAME" was developed to perform heat transfer analyses. The program output consists of the temperature and heat flow distribution through the frame and spacer.

Spacer Design
The use of fiberglass, butyl rubber or an edge-welded stainless steel strip as a spacer was determined to reduce overall window heat loss by seven per cent in standard double-glazed windows, and by 12 per cent in low-emissivity double-glazed windows. These results constitute a 20 to 30 per cent reduction in frame heat loss alone. It was concluded that high-performance glazing units require high thermal performance spacers. Results also indicate that the use of insulated spacers decreases the tendency for condensation on the interior side of the glazing.



Wood Window Frame

Frame Design
Compared to aluminum, frame materials such as PVC, wood or fiberglass can reduce overall heat loss through windows by up to 36 per cent. PVC with polyurethane-foam-fill insulation was determined to be the best combination of framing materials, decreasing overall heat loss by 43 per cent.

Bite Design
Incorporating a large bite in the window frame construction increases total resistance only when a highly conductive spacer is employed. When an improved spacer of relatively low thermal conductivity is used, the overall window thermal resistance decreases.

Additional Information

Final Report:
Enermodal Engineering Ltd. 1986. The Effect of Frame Design on Window Heat Loss - Phase I. EMR Report No.: T2-W3-86-6253. Ottawa, Ont.: Energy, Mines and Resources Canada.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

COMPUTER ANALYSIS OF IMPROVED WINDOW FRAME DESIGNS - PHASE II

Contractor
Enermodal Engineering Ltd.
368 Phillip Street, Unit 2
Waterloo, Ontario
N2L 5J1

Principal Investigator
S.C. Carpenter (519) 884-6421

Background

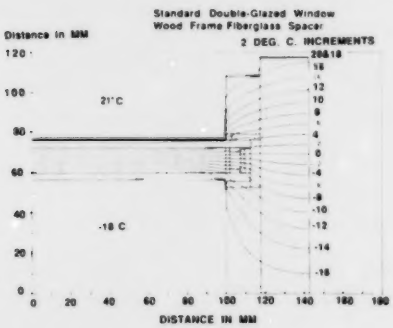
During the first phase of this project (see DSS File No. 23216-6-6253/01, "The Effect of Frame Design on Window Heat Loss - Phase I"), a numerical method was developed for the analysis of different types of window frames and spacers. In order to aid designers, the methodology was further developed to a computational program, FRAME, which models heat loss through residential and commercial window frame systems. The computer program calculates energy flows within window systems by applying a finite-difference analysis.

Objectives

To improve the thermal analysis capabilities of the FRAME program

To make the FRAME program user-friendly by including graphic input and output and a program user's manual

To test and debug the program to improve its accuracy



Results

As a result of this project, the FRAME program now has Computer Aided Design (CAD) flexibility in graphical data input, and can produce plots of isotherms and lines indicating constant heat flow either to the computer screen or to a plotter. The program can also display temperature and heat flow matrices throughout the window frame. Program improvements allow users to estimate possible energy savings of one material or configuration over other designs for different operating conditions. The new User's Manual contains programming details.

Copies of the FRAME program are available to users at no cost. A French edition of FRAME is also being prepared. A User Service for the computer program is sponsored by Energy, Mines and Resources.

Additional Information

Final Report:
Enermodal Engineering Ltd. 1987. A Finite Difference Program to Evaluate Thermal Performance of Window Frame Systems. EMR Report No. T2-W3-87-6162. Ottawa, Ont.: Energy, Mines and Resources Canada.

DSS File No.: 23283-7-6162/01
EMR File No.: CN7161-E4
Contract Start Date: Aug 87
Completion Date: Mar 88
Project Value: $44,550
EMR Funding: $34,338

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

IMPROVEMENTS TO THE ENERPASS COMPUTER PROGRAM

Contractor
Enermodal Engineering Ltd.
368 Phillip Street, Unit 2
Waterloo, Ontario
N2L 5J1

Principal Investigator
S.C. Carpenter (519) 884-6421

DSS File No.: 23283-7-6173/01
EMR File No.: CN7161-E5
Contract Start Date: Sep 87
Completion Date: Nov 88
Project Value: $32,000
EMR Funding: $24,657

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
In order to incorporate passive solar technology into their buildings, designers must be confident that solar features are properly sized, cost-effective, and will not cause occupant discomfort. A computer simulation program entitled ENERPASS is available to aid designers in building thermal analysis.

Originally developed by Enermodal Engineering, ENERPASS simulates a building's thermal performance by using hourly weather data, and already includes various passive solar concepts. Response to the program has been excellent and users have suggested that ENERPASS could be improved by adding mechanical system options and by modifying program output results.

Objectives
To enhance and improve ENERPASS by developing analytical models of mechanical system options such as temperature-dependent heat-recovery ventilators, combined heating systems consisting of central fan cooling with perimeter heating, and integrated mechanical systems

To add the new mechanical system models to ENERPASS and test for accuracy of enhancement

To modify the input and output structure of the program to make it more user-friendly

Results
Various new models have been developed and added to the program. The accuracy of the program simulations is now being checked before the new version of ENERPASS is released. ENERPASS 3.0 and an updated User's Manual are expected to be available by November, 1988.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

DESIGN AND DEVELOPMENT OF A LAMINAR AIR FLOW HIGH-PERFORMANCE WINDOW

Contractor
G.K. Yuill and Associates Ltd.
1441 Pembina Highway
Winnipeg, Manitoba
R3T 2C4

Principal Investigator
Gren Yuill (204) 474-2461

DSS File No.: 57SZ.23216-6-6093
EMR File No.: CN7161-G1
Contract Start Date: Jun 86
Completion Date: Mar 87
Project Value: $40,657
EMR Funding: $40,657

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Ventilation windows contain passages between the panes through which ventilation air can be brought into rooms. The theoretical concept behind this approach is sound. However, there are practical difficulties associated with these windows, such as maintaining the laminar air flow, moisture problems and balancing heat loss against house ventilation requirements. Feasibility studies of commercial product development of ventilation windows and their applications in Canada should be evaluated.

Objectives
To develop a theoretical method of analyzing ventilation window thermal performance and to establish criteria for laminar air flow conditions

To design, construct and install a prototype laminar air flow window and to develop a suitable method for ventilation while observing the practical implications of the air flow window system, and to analyze the economics of the window and ventilation system

Results
The figure shows the installation of the prototype ventilation window. The thermal performance of the window was predicted using a detailed finite-difference computer model. The table shows the thermal performance of a laminar air flow window with 12.7 mm space between the inside and middle panes. The incoming ventilation air was preheated to about 12°C during the daytime.

The concept was tested by installing a window in a house. After one winter of operation, no practical difficulties were encountered with the prototype. The additional manufacturing cost is estimated at $40/m² of window, which may be substantially reduced through mass production.

Ventilation Window

Glazing System	Air Temp Rise °C	U-Value W/(m²K)
1. Conventional triple-glazed window	0	1.85
2. Triple-glazed with air flow	12	1.17
3. Triple-glazed with air flow, low-E coating on middle pane	9	0.83

Thermal Performance of Laminar Air Flow High-Performance Windows

Additional Information

Final Report:
G.K. Yuill and Associates Ltd. 1987. Laminar Air Flow High-Performance Window. EMR Report No. T2-W4-86-6093. Ottawa, Ont.: Energy, Mines and Resources Canada.

Conference Paper:
G.K. Yuill and Associates Ltd. 1988. Laminar Air Flow High-Performance Window. Proc. Solar Energy Society of Canada Conference '88.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

PERFORMANCE MODELLING USING A CALIBRATED MODEL

Contractor
G.K. Yuill and Associates Ltd.
1441 Pembina Highway
Winnipeg, Manitoba
R3T 2C4

Principal Investigator
Gren Yuill (204) 474-2461

DSS File No.: 23216-6-6258/01
EMR File No.: CN7161-G3
Contract Start Date: Aug 86
Completion Date: Dec 87
Project Value: $12,865
EMR Funding: $9,836

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Since passive solar concepts are generally integrated into building construction, their actual performance is difficult to evaluate because system energy output cannot be easily measured. In a previous contract with the National Research Council (NRC), G.K. Yuill and Associates conducted a performance monitoring study of a passive solar building. An important facet of that study was an attempt to develop a calibrated modelling technique using monitored data from passive solar commercial buildings.

As a continuation of the previous NRC contract, the suitability of the calibrated modelling technique as a design tool for estimating the approximate contribution of passive solar energy to total heating requirements will be assessed.

Objective
To develop and demonstrate the calibrated modelling technique for evaluating the contribution of passive solar energy to the total heating load of a building

Results
A calibrated model was generated using monitored data from several thermal performance parameters, such as air temperature, heating loads and ambient conditions. A building energy analysis was performed using the BLAST computer program. Predicted performance data from BLAST and the actual monitored data were compared. The BLAST program data input was then improved, or calibrated, until the energy usage compared favorably with the monitored data.

The results showed that accurate modelling can be obtained. The contractor concluded that although the technique is accurate, it is not practical as a design tool because too much computational time and data collection effort are required to develop the initial calibration.

Additional Information

G.K. Yuill and Associates Ltd. 1986. Performance Monitoring of the Smith Carter Partners Office Building. Report for the National Research Council, Solar Energy Program.

Final Report:
G.K. Yuill and Associates Ltd. 1987. Development and Demonstration of Calibrated Modelling as a Technique to Evaluate the Performance and Cost-Effectiveness of Passive Solar Office Building Systems. EMR Report No. T2-W3-86-6258. Ottawa, Ont.: Energy, Mines and Resources Canada.

Conference Paper:
G.K. Yuill and Associates Ltd. 1988. Performance Modelling Using a Calibrated Model. Proc. Solar Energy Society of Canada Conference '88.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

ELECTROCHROMIC DEVICES FOR OPTICALLY SWITCHING WINDOWS

Contractor
INRS-Énergie
Université du Québec
1650 Montée Ste-Julie
Varennes, Quebec
J0L 2P0

Principal Investigator
Lê H. Dao (514) 468-7744

DSS File No.: 23216-6-5092/01
EMR File No.: CN7161-J1
Contract Start Date: May 86
Completion Date: Feb 88
Project Value: $62,982
EMR Funding: $62,982

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Recent advancements in high-performance window technology have spurred interest in switchable electrochromic coatings for glazings. By this process, the light-absorptive properties of electrochromic material are electronically altered. Electrochromic coatings also exhibit low-emissivity properties which reduce radiative heat losses.

Electrochromic materials may be composed of either organic or inorganic compounds. INRS-Énergie has laboratory facilities suitable for developing low-cost organic polymer electrochromic materials.

Objectives
To prepare electrochromic films using electrochemical polymerization of aromatic compounds

To characterize the chemical, optical and colour/decolouration properties of electrochromic materials

To optimize the switching properties of electrochromic materials by varying the voltage and chemical structure

Results
Fifty electrochromic test specimens were prepared which are based on an organic polymer electrochromic film and a semi-solid electrolytic film. The films are sandwiched by a pair of conducting transparent electrodes deposited on two panes sealed at the edges. The films are uniform in thickness, and when voltage is applied, colour/decolouration shows a uniform light transmission. The chemical composition of the organic polymers shows stability for a temperature range of -30°C to 50°C. Optical characteristics such as reflection and transmittance spectrums were measured as a function of applied voltage.

The researchers concluded that it is possible to fabricate prototype organic polymer electrochromic samples at a lower cost than with other techniques.

Additional Information

Final Report:
Dao, L.H. 1988. Systèmes électrochromiques pour la commutation optique des fenêtres. EMR Report No. T2-W1-86-6092. Ottawa, Ont.: Energy, Mines and Resources Canada.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

DEVELOPMENT OF A PROTOTYPE ELECTROCHROMIC OPTICALLY SWITCHING WINDOW

Contractor
INRS-Énergie
Université du Québec
1650 Montée Ste-Julie
Varennes, Quebec
J0L 2P0

Principal Investigator
Lê H. Dao (514) 468-7744

DSS File No.: 23283-7-6207/01
EMR File No.: CN7161-J3
Contract Start Date: Nov 87
Completion Date: Nov 89
Project Value: $245,401
EMR Funding: $75,401

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Department of Supply and Services Canada under the Unsolicited Proposals Program and by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
A worldwide interest has arisen in the development of various techniques for preparing electrochromic films. In a previous Energy, Mines and Resources contract, INRS-Énergie identified methods for preparing solid organic polymer electrochromic materials. The feasibility of using these materials in the manufacture of electrochromic switchable glazings was demonstrated.

INRS now possesses the capability to produce organic-based compounds with electrochromic properties. The development of a larger prototype electrochromic sample will enable the organization to prove the practicality of this innovative Canadian approach.

Objectives
To construct a prototype electrochromic glazing sample sized 40 by 40 cm

To determine the factors which affect prototype operation, such as applied voltage and temperature rise, and to analyze the thermal performance of the glazing

To characterize the optical properties and determine the response characteristics (transmittance as a function of applied voltage), to evaluate the durability of the prototype glazing and to determine minimum colour/decolouration cycling time

To perform an economic analysis of the prototype unit

Results
Prototype electrochromic samples sized 10 by 10 cm have been prepared.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

DEVELOPMENT AND CONSTRUCTION OF A WINDOW WITH AN INCORPORATED INSULATING ROLLER SHADE

Contractor
Insulor Inc.
P.O. Box 365
Hawkesbury, Ontario
K6A 2S1

Principal Investigator
Marcel Dubé (613) 632-4989

DSS File No.: 23216-6-6254/01
EMR File No.: CN7161-J2
Contract Start Date: Oct 86
Completion Date: Mar 87
Project Value: $16,150
EMR Funding: $12,675

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Despite triple-glazing and low-emissivity coatings, windows continue to be the weakest thermal point in the building envelope. Although insulating shutters reduce window heat loss, they are cumbersome, susceptible to weather damage on the exterior, and cause condensation problems if they don't seal well on the interior. Little work has been done in Canada on the use of movable insulation between the glazings.

Objective
To develop windows with built-in insulating roller shades and to demonstrate the insulating value improvements

Results
The construction of a roller shade was successfully completed. As the diagram indicates, an aluminum-coated polyester film roller shade is placed between the inner and outer panes of the window.

When the roller shade is lowered, the film is extended in a U-shape with the help of a rod which rests on the film. The low-emissivity metalized film reduces radiation losses while the three air spaces it creates reduce convective losses.

Tests conducted at the National Research Council on a sliding window and fixed window gave the following results at -18°C:

	R-Value
Both windows, roller shade up	0.38 $m^2 \cdot K/W$
Sliding window, roller shade down	1.21 $m^2 \cdot K/W$
Fixed window, roller shade down	1.37 $m^2 \cdot K/W$

Roller Blind Window

When the roller shade is raised, the insulating value is the same as that of a double-glazed window. However, when the roller shade is lowered, the insulating value is increased by 320 per cent for the sliding window and 360 per cent for the fixed window.

The company claims that since the completion of this project, it has incorporated the concept into a sloped unit for greenhouses or sunspace roofs.

Additional Information

Final Report:
Dubé, M. 1987. Development and Construction of a Window with an Incorporated Insulating Roller Shade. EMR Report No. T2-W4-86-6254. Ottawa, Ont.: Energy, Mines and Resources Canada.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

SIMPLIFIED PASSIVE SOLAR BUILDING PERFORMANCE MONITORING PROGRAM

Contractor
Memphremagog Community
Technology Group
R.R. No. 4
Masonville, Quebec
J0E 1X0

Principal Investigator
Ron Alward (514) 292-5663

DSS File No.: 23216-6-6117/01
EMR File No.: CN7161-M1
Contract Start Date: May 86
Completion Date: Sep 87
Project Value: $49,133
EMR Funding: $49,133

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Developed at the National Research Council, the Level B performance evaluation procedure permits the accurate calculation of passive solar energy contribution to the total heating load of buildings throughout the year. Comprised of hourly data measurements, Level B monitored data for approximately 20 houses have significantly contributed to the understanding of passive solar concepts by the research community. However, little of Level B monitoring data have been useful to building designers in their efforts to commercialize passive solar technology.

A simplified monitoring procedure could be developed to provide more useful data to design professionals once their information needs have been identified. The monitoring of a large number of residential houses across Canada will help enhance consumer confidence in passive solar technology.

Objectives
To re-assess the information requirements of users for the commercialization of passive solar concepts

To develop a simplified, low-cost monitoring procedure for passive solar performance evaluation, based on supplying those information needs

To recommend a simplified monitoring program for residential houses to provide useful information on passive solar performance for the design community

Results
A survey of potential users revealed that most of their needs could be met by implementing a low-level monitoring program. In addition, information about a number of passive solar houses and how they perform in different Canadian locations would provide a base for comparison. It was estimated that low-level monitoring of about 60 buildings located across the country would provide enough information for comparison and validation. The project would also increase the credibility of passive solar applications.

Low-level monitoring relies on manual collection of data. Energy usage data would be gathered from utility meters, and ambient and interior temperatures would be measured once a day. With this minimal information, thermal performance indices could be generated to represent the overall behaviour of the building on a daily average or monthly basis.

Costs of conducting low-level monitoring of a building are estimated at $5,000/yr. This figure represents a significant cost reduction when compared to the existing Level B monitoring procedure.

Additional Information

Final Report:
Alward, R. 1986. Passive Solar Building Performance Monitoring Program. EMR Report No.: T2-W10-86-6117. Ottawa, Ont.: Energy, Mines and Resources Canada.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

PREPARATION OF PASSIVE SOLAR HOME PERFORMANCE BRIEFS

Contractor
Memphremagog Community
Technology Group
R.R. No. 4
Masonville, Quebec
J0E 1X0

Principal Investigator
Ron Alward (514) 292-5663

Background
In 1982-83, the National Research Council's Passive Solar Program initiated Level B performance monitoring of different types of passive solar houses across Canada. Since then, an impressive amount of information has been obtained from approximately 20 monitored passive solar houses.

However, an initial users survey conducted by the investigators during a previous project (see DSS File No. 23216-6-6117, "Simplified Passive Solar Building Performance Monitoring Program") indicates that little monitoring information has been transferred to any of the audiences who might influence the commercialization of passive solar technologies.

Objectives
To transfer information obtained by the Level B performance monitoring program to groups such as building professionals, home-owners and home-buyers to accelerate the commercialization of passive solar technology

To increase awareness in the building industry and general public about the potential of passive solar technologies

Results
Eight fact sheets, aimed at builders, developers and passive solar designers, will highlight design features and monitoring results of houses examined under the Level B monitoring program. A ninth fact sheet will explain the principles behind the monitoring program and summarize the results of the evaluation program.

The fact sheets will be available in English and French in the fall of 1989.

DSS File No.: 23283-7-6172/01
EMR File No.: CN7161-M2
Contract Start Date: Aug 87
Completion Date: Oct 88
Project Value: $59,096
EMR Funding: $59,096

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

ENERGY PERFORMANCE EVALUATION AND LABELLING REQUIREMENTS FOR WINDOWS

Contractor
Ontario Research Foundation
Sheridan Park Research Community
Mississauga, Ontario
L5K 1B3

Principal Investigator
David Bailey (416) 822-4111

DSS File No.: 23283-7-6249/01
EMR File No.: CN7161-P3
Contract Start Date: Nov 87
Completion Date: Mar 89
Project Value: $150,000
EMR Funding: $150,000

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Dramatic change in window glazing system design is indicated by the wide variety of high-performance glazings that are available. Examples include low-emissivity coatings, anti-reflective coatings, plastic films, low-iron glass, infrared transparent glazings and gas-filled sealed units. Better spacer and frame materials also contribute to the development of this technology.

Increasingly complex glazing systems escalate a need for more complex performance evaluation and identification procedures. A standardized method of comparative performance identification is also required by the consumer to make informed purchasing decisions. The window industry has expressed strong interest in developing performance evaluation and labelling requirements for windows. Energy performance labelling would also assist electric utility companies in offering incentives for energy-efficient units with the potential to reduce peak electric power demand.

Objectives
To gather information on window evaluation and labelling parameters and international activities in this regard

To organize a steering committee consisting of manufacturers, user groups and the technical/regulatory community to identify a window labelling procedure

To organize working groups as specified by the steering committee and to co-ordinate their activities in developing methods for evaluating window performance and reliability, and to establish labelling requirements

To assess and recommend a program for evaluating and labelling the energy performance of windows

Results
A steering committee has been established to prepare a detailed work plan for this project.

A literature review of methods employed to determine thermal performance was performed, and a labelling procedure has been suggested.

The final report is expected in March, 1989. It will be available for public comment.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

DEVELOPMENT OF GYPSUM WALLBOARD WITH PHASE-CHANGE MATERIAL THERMAL STORAGE

Contractor
Parinova Inc.
2975 Douglas Avenue
Montreal, Quebec
H3R 2E2

Principal Investigator
Jean Paris (514) 340-4921

DSS File No.: 23216-6-6134/01
EMR File No.: CN7161-P1
Contract Start Date: May 86
Completion Date: Oct 88
Project Value: $169,186
EMR Funding: $169,186

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

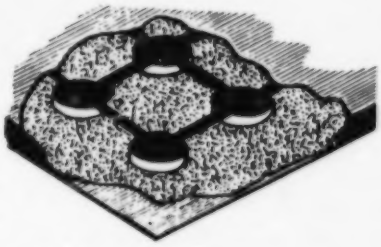
Background
Incorporating phase-change material (PCM) in wallboard is an efficient method of providing thermal storage in buildings. PCM absorbs and releases heat while changing its state from solid to liquid, and from liquid to solid. Gypsum wallboard is ideally suited for the containment of PCM because of its large surface area distribution within buildings, as well as wide existing manufacturing and marketing facilities. Parinova has developed gypsum wallboard with encapsulated PCM for providing higher thermal storage capacity. Phase-change materials are now sought which feature stable physical properties within the comfort temperature range, cost-effectiveness and an easy encapsulation procedure.

Objectives
To perfect the design and incorporation procedure for encapsulated PCM within gypsum drywalls

To define the fabrication procedure and evaluate the procedure for factory production

To determine the additional expense of manufacturing PCM gypsum wallboard compared to conventional wallboard

To perform a thermal and energy economics evaluation study of prototype PCM gypsum wallboard in test modules and compare its performance with conventional gypsum wallboard



PCM capsule in gypsum board

Results
Because its phase-change temperature is within a range of 18°C to 22°C, polyethylene glycol (PEG, Carbowax-600) was chosen as a suitable PCM. Solid sticks of PEG were formed, encapsulated in aluminum foil and inserted within grooves cut into manufactured sheets of wallboard. With about 70 grooves per m² of wallboard, the finished product consists of about 11 per cent PCM by volume. Prototype PCM gypsum wallboard was fabricated at Westroc Industries.

Four test huts were constructed to test the thermal performance and installation procedures using PCM and conventional gypsum wallboard. An economic evaluation and analysis of PCM wallboard thermal performance are in progress.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

DEVELOPMENT OF AN EVACUATED HIGH THERMAL PERFORMANCE WINDOW

Contractor
Parker Design Ltd.
353 Regal Briar Street
Whitby, Ontario
L1N 6P4

Principal Investigator
Ken Parker (416) 576-8586

DSS File No.: 23216-6-6256/01
EMR File No.: CN7161-P2
Contract Start Date: Oct 86
Completion Date: Nov 88
Project Value: $181,750
EMR Funding: $137,924

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
The use of standard double-glazed windows has a significant impact on heat losses from buildings. For conventional units, radiation heat transfer accounts for about 65 per cent of heat losses while convection and conduction between glazings account for about 35 per cent. A low-emissivity coating reduces the radiation losses significantly, to less than 20 per cent of net heat losses. Conductive and convective losses subsequently become predominant. Two methods are available to reduce convective and conductive losses: replacing the air between glazings with an inert heavy gas such as argon or krypton; or evacuating the air between the glazings.

In 1985, the National Research Council supported a feasibility study by Parker Design to develop a prototype evacuated-glazing panel. Key technical problems were identified. A commercial product could be developed with more reliable vacuum-tight seals based on improved glass-to-metal bonding techniques and a pilot manufacturing process.

Objectives
To develop a reliable glass-to-metal bonding technique, a flexible metal spacer and a vacuum process

To perform a global market survey of evacuated-glazing window products

To fabricate and test a prototype evacuated-glazing unit

To design a layout for an automated plant for evacuated-glazing unit production

Results
The most important component of evacuated-glazing units is a seal to maintain a reliable vacuum between the panes of glass. An innovative flexible metal band spacer was developed. Attempts at metalizing the glass for a good glass-to-metal seal were unsuccessful. An ultrasonic soldering method is now being tried. A suitable vacuum process has been selected which involves an insertion type of vacuum probe. Sample evacuated-glazing units will be fabricated, depending on the success of the glass-to-metal seal.

A preliminary global market survey for insulated glazing units has identified the manufacturers in most countries, but no data are available on the commercial availability of evacuated units or the technology used to produce them.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

IMPROVED GAS-FILLING AND GAS RETENTION TECHNOLOGY IN SEALED INSULATED GLASS GLAZING PANELS

Contractor
Repla Ltd.
482 South Service Road East
Oakville, Ontario
L6J 2X6

Principal Investigator
Don Taylor (416) 844-1271

DSS File No.: 23216-7-6244/01
EMR File No.: CN7161-R1
Contract Start Date: Nov 87
Completion Date: Oct 88
Project Value: $80,675
EMR Funding: $61,507

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Low-emissivity, double-glazed windows filled with inert gas between the glazings generate a 40 to 50 per cent improvement in thermal resistance compared to conventional double-glazed windows. Current gas-filling technology employs the principle of density difference: the introduction of the inert gas displaces the air from the cavity. Although this system has proven satisfactory, complete air evacuation is not assured.

The improved thermal performance of gas-filled windows depends on maintaining a high gas level during their service life. A greater understanding of the permeability characteristics of sealants and spacer materials is required to ensure that the new generation of gas-filled, low-emissivity windows maintain their improved level of performance over time.

Objectives
To develop a new procedure for gas-filling sealed glazing units

To develop transparent thermoplastic glazing panels with the use of low-permeable organic sealants and adhesives

To gas-fill cavities in sealed insulated glass panels to a consistent minimum level of 95 per cent and to test the glazing unit to determine long-term leakage rates

To develop supporting gas-filling equipment to ensure total removal of air and the positive introduction of an inert gas

Results
Twenty standard-sized insulated glazing units were fabricated. Following tests, it was observed that gas-filling rates, purge volume requirements and the resultant gas-filling purity level depend on the method used to introduce the gas. It was determined that the evacuation of air from the spaces and a subsequent introduction of inert gas produces higher purity levels and requires less purge volume.

Work is continuing on evacuating the units in a vacuum chamber, filling them with gas until the pressure equals the exterior atmosphere, and then sealing the entry ports while still in the vacuum chamber. This method avoids mixing air and gas within the units.

Since this project involves proprietary research, the final report will contain only generic results. These are expected in October, 1988.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

ADVANCED PASSIVE SOLAR TECHNOLOGY: THE WINDOW MARKET IN THE UNITED STATES AND CANADA

Contractor
Secor Inc.
922-555 René-Lévesque Blvd West
Montreal, Quebec
H2Z 1B1

Principal Investigator
Michel Cloutier (514) 861-9031

DSS File No.: 23216-6-6093
EMR File No.: CN7161-S1
Contract Start Date: Dec 85
Completion Date: Aug 86
Project Value: $10,000
EMR Funding: $10,000

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
The purpose of this project was to provide statistical information on the Canadian and U.S. window markets. Statistics were collected from manufacturers, suppliers and experts in the residential and non-residential construction sectors.

Objectives
To document industry statistics about the residential and non-residential window market, to estimate statistics for attached sunspaces, and to forecast these three markets for the remainder of the century

Results
The 1984 North American window market totalled about 1,160 million square feet of sales. This figure is expected to grow by about five per cent by 2001. In 1984, window spaces installed in Canada amounted to 57 million square feet - 42 million residential and 12 million non-residential - about one-twentieth of the U.S. figure. Renovation/retrofit sales were about equal to new construction sales at 45 to 50 per cent.

In 1984, new windows installed in Canada in the residential market totalled 22 million square feet. Renovation/retrofit installations accounted for another 20 million square feet (approximately 45 per cent of residential installations). Housing starts are expected to decline by 55 per cent by 2001, resulting in a decline in the forecasted new window market to 18 to 19 million square feet. The renovation/retrofit market is expected to increase its share of the market to 65 or 70 per cent (35 to 43 million square feet). The Canadian residential market data for 1984 show that 75 per cent of windows were sealed glazing units, out of which 58 per cent were double-glazed and 16 per cent were triple-glazed.

In 1984, new windows in the non-residential market totalled 9 million square feet while renovation/retrofit windows totalled 3 million square feet. Canadian demand for non-residential window sales is expected to be 12 to 14 million square feet by 2001. Renovation/retrofit sales are expected to show only a mild increase. The non-residential window data show that 80 per cent of windows are sealed glazing units. By 1991, the commercial sector window market is expected to grow by three per cent.

In Canada, 20 per cent of sunspaces are contractor-built while 80 per cent were owner-built. The total 2001 market for sunspaces in Canada is expected to be 125,000 units. Sunspaces will be most prevalent in high income bracket houses. The total number of U.S. sunspaces expected in the year 2000 is 2.5 million, 40 per cent of which are now in place.

Additional Information

Final Report:
Cloutier, M. 1986. Advanced Passive Solar Technology: The Window Market in the United States and Canada. EMR Report No. T2-W7-86-6253. Ottawa, Ont.: Energy, Mines and Resources Canada.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

HIGH-PERFORMANCE WINDOWS FROM PYROLYTIC DEPOSITION OF FLUORINE-DOPED TIN OXIDE ON GLASS: U-VALUES AND ELECTRICAL CONTACTS

Contractor
Simon Fraser University
Department of Physics
Burnaby, B.C.
V5A 1S6

Principal Investigator
K. Colbow (604) 291-4465

DSS File No.: 23216-6-6264
EMR File No.: CN7161-S2
Contract Start Date: Sep 86
Completion Date: Mar 88
Project Value: $55,880
EMR Funding: $55,880

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background

Window temperatures can be raised with "heatable" glass, using a coating similar to conventional low-emissivity (low-E) glass. An invisible thin metallic coating is sputtered onto one of the inner surfaces of a sealed insulating glass unit. Because the metal oxide coating is electrically conductive, the surface heats up when a current is applied and the window functions as a large radiant heater. Heatable glass can heat rooms or defog and defrost windows.

Under a previous contract with the National Research Council (NRC), Simon Fraser University (SFU) prepared low-E glass by spray pyrolysis in which fluorine-doped tin oxide (SnO_2:F) was sputtered on a hot glass substrate (400°C to 500°C). Samples of the glass from that project were used in the current study.

Objectives

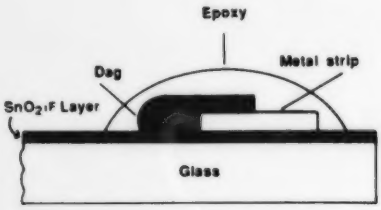
To determine the R-value of double-glazed windows with one SnO_2:F coating, to measure the optical properties of SnO_2:F coated glass for comparison with commercially-available low-E coated glass, and to investigate a procedure for improved electrical contacts

Results

The heat loss coefficient (U-value) of the SnO_2:F-coated (SFU) window was 2.50 W/(m²K) without power supply and 2.70 W/(m²K) with an electrically-heated inner glazing. These measurements were taken at the NRC Window Testing Laboratory.

Product	Film Thickness (μm)	U-Value W/(m²K)	R-Value ft²hF/Btu	Emissivity
SFU	0.37	2.50	2.27	0.12
GLA-VERBEL	0.82	1.96	2.90	0.15
PPG	0.075	2.27	2.50	0.31

Table 1. Comparison of Double-Glazed Low-E Coated Windows



Electrical contacts on tin oxide coated glass

The electric contacts between the conducting low-E film and the electric supply metal strip (known as dag) were constructed of Carbon Dag or Silver Dag (commercial products). Carbon Dag combined with tin-plated copper tape was found to be a cheaper and more reliable contact than conventional Silver Dag. Compared to Silver Dag, Carbon Dag contacts will lower costs by about 24 per cent without compromising performance.

Contact Description	Electrical Resistance
Tin-plated Copper Foil and Silver Dag	34.8 Ω
Tin-plated Copper Foil and Carbon Dag	36.9 Ω

Table 2. Resistance Measurement for Various Contacts

Additional Information

Final Report:
Colbow, K. 1986. High-Performance Windows from Pyrolytic Deposition of Fluorine-Doped Tin Oxide on Glass: U-Values and Electrical Contacts. EMR Report No. T2-W4-86-6264. Ottawa, Ont.: Energy, Mines and Resources Canada.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

ELECTROSTATIC DEPOSITION OF TIN OXIDE COATINGS ON GLASS USING AN AQUEOUS-CHARGED AEROSOL

Contractor
Simon Fraser University
Department of Physics
Burnaby, B.C.
V5A 1S6

Principal Investigator
S. Roy Morrison (604) 291-4465

Background

Simon Fraser Energy Research Institute has been involved in developing techniques for depositing low-emissivity (low-E) coatings on glass, with an emphasis on the use of fluorine-doped tin oxide (SnO_2:F). As well as improving optical properties, SnO_2:F as a coating permits the development of "heatable" glass. Uniformity and high electrical conductivity stand as major low-E requirements.

One of the suitable deposition techniques for SnO_2:F coatings is the electrostatic approach in which an electric field is used to control the coating material deposition by maintaining the proper droplet size. This work follows "A Study on Heat-Reflecting Tin Oxide Coatings on Glass", conducted for the National Research Council from 1982 to 1985, with a principle aim to produce low-cost and uniform transparent coatings for application in energy-efficient windows.

Objectives

To develop an electrostatic deposition technique for low-E coatings on glass

To design and test the electrostatic deposition system

Results

The electrostatic deposition method for SnO_2:F coatings was theoretically analyzed using a mathematical model. Operating parameters, such as laminar flow characteristics, flow velocity, glass surface temperature, droplet size, electric field parameters and spray conditions, were determined.

An experimental set-up was designed and fabricated for electrostatic deposition using the guidelines provided by the theoretical model. Prototype low-E coated glass using a SnO_2:F spray was produced, but the thickness of coating was uneven and the quality was poor. The theoretical model is being refined, and the experimental set-up and the operating parameters are being modified to generate better quality coating.

Testing and production of prototype low-E coated glass using electrostatic deposition system is in progress.

DSS File No.: 23216-6-6264/01SZ
EMR File No.: CN7161-S2
Contract Start Date: Sep 86
Completion Date: Oct 88
Project Value: $84,746
EMR Funding: $84,746

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

REDESIGN OF THE SOLAR LIGHT PIPE FOR MULTI-STOREY ILLUMINATION

Contractor
TIR Systems Ltd.
3935 2nd Avenue
Burnaby, B.C.
V5C 3W9

Principal Investigator
Lorne Whitehead (604) 294-8477

DSS File No.: 23283-7-6127/01
EMR File No.: CN7161-T4
Contract Start Date: Jul 87
Completion Date: Dec 88
Project Value: $226,075
EMR Funding: $161,756

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
During the first commercial demonstration of light pipe technology at the Victoria Park Place office building in Willowdale, Ontario, estimates of lighting load electrical savings were in the order of 10,000 kW·h/yr. Cost-effectiveness and optimization of components of the system were major observations for the commercial success of this innovative Canadian technology. This project was initiated for the design and development of a cost-effective, generic solar light pipe system for multi-storey applications and to demonstrate its potential in a high-profile building.

Objectives
To design and construct a light pipe illumination system based on easily installed components

To demonstrate the feasibility of a multi-storey rooftop solar collection system that feeds light to several floors

To analyze the economic and technical feasibility of the light pipe system for successful commercial applications

To demonstrate light pipe technology in a high-profile project to illustrate user benefits

Results
A new version of the solar light pipe system is being installed at Victoria Park Place. The automatic control system for the heliostats has been redesigned from one central computer controlling the whole array of focusing mirrors to micro-computers for each individual heliostat and one central micro-computer for monitoring light levels and adjusting supplemental lighting. Converging mirror components have been redesigned so that they can be fabricated using a casting process rather than requiring precision machining. A scaled-down, one-third model of the light pipe system was constructed for initial testing.

Installation of the light pipe system is progressing with the construction schedule of the building.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

DEVELOPMENT OF A THEORETICAL DESIGN METHOD FOR DOMESTIC SOLAR SPACE HEATING SYSTEMS

Contractor
Tang G. Lee Architect
20 Dalbrook Bay N.W.
Calgary, Alberta
T3A 2G9

Principal Investigator
T.G. Lee (403) 288-0871

DSS File No.: 57SZ.23216-6-6091
EMR File No.: CN7161-T1
Contract Start Date: Jun 86
Completion Date: Mar 87
Project Value: $55,450
EMR Funding: $55,450

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Recent progress in the application of combined active and passive concepts in buildings indicates a promising future for solar hybrid technology. Building-integrated systems which employ active-charge/passive-discharge (AC/PD) storage methods are achieving better thermal performance and shorter payback periods. It is estimated that building-integrated hybrid solar designs have the potential to provide at least 50 per cent of total heating demands with payback periods of four to five years, based only on diurnal cycles.

An AC/PD storage system uses warm fluid from solar collectors or sunspaces to heat building elements such as walls or floors, which in turn dissipate heat to the room air with a phase lag. Improved control over heat transfer minimizes overheating problems.

The addition of a theoretical model of heat transfer and thermal performance to a widely used design tool such as HOTCAN and HOT2000 would greatly contribute to the development of solar hybrid systems.

Objectives
To develop a theoretical model of the AC/PD method to estimate the overall thermal behaviour of building-integrated systems

To use the theoretical method to develop a user-interactive computational program as a design tool to be compatible with HOTCAN and HOT2000

To illustrate the use and analysis of the design method

Results
As illustrated in the figure, a two-dimensional heat transfer model was developed for the storage structure. The AC/PD design method was generated as a computer sub-routine which may be used with the HOTCAN program. The method involves the input of data which

Basic Storage Unit

describe the building load, the active solar collection system and the AC/PD storage system. HOTCAN can perform the building load and active solar collection system calculations. After employing the necessary input data, the AC/PD program provides the thermal performance and an economic analysis of a combined load-collection-storage system. The design method is used for open-circulation air-based systems and closed-circulation water-based systems.

The computer program developed in this work is representative of actual building-integrated system operation, but the theoretical design method has not been validated. However, it has been used by the contractor in the design of a solar-heated building.

Additional Information

Final Report:
Byrne, A.P., K.Y. Chow and T.G. Lee. 1986. Development of a Seasonal Method for Domestic Solar Space Heating Systems, Final Report and AC/PD Design Method User's Manual. EMR Report No. T2-W3-86-6091. Ottawa, Ont.: Energy, Mines and Resources Canada.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

THERMAL IMPROVEMENT OF "VISION CONTROL" WINDOWS

Contractor
Unicel Inc.
88 de Vaudreuil Road
Boucherville, Quebec
J4B 5G4

Principle Investigator
Earl Bilgen (514) 655-1580

DSS File No.: 57SZ.23216-6-6136
EMR File No.: CN7161-U1
Contract Start Date: Jul 86
Completion Date: Jul 87
Project Value: $49,000
EMR Funding: $36,750

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Among the various shading devices used for thermal control of buildings, venetian blinds are particularly versatile because they allow selective control over window characteristics with the adjustment of the angle of the louvers. Unicel had previously developed and marketed a venetian blind window system trade-marked "Vision Control" which incorporates louvers between two hermetically sealed glass panes. A detailed heat transfer simulation model was required to study the thermal and optical characteristics of Vision Control windows to improve and modify their thermal performance.

Objectives
To improve the thermal and optical characteristics of Vision Control windows by conducting detailed thermal analysis for the development of a computer model

To build an improved Vision Control window system and test its thermal performance

Results
The detailed heat transfer analysis and test results of the window system provided the following:

(i) Experimental verification showed that the numerical model satisfactorily predicts the thermal performance of the Vision Control window system.
(ii) It is possible to control the louver position instantaneously at an optimum angle, reducing auxiliary energy requirements to a minimum.
(iii) Results from typical summer and winter days indicate energy savings of 91 per cent during the cool seasons and 70 per cent during the warm seasons.
(iv) System thermal resistance could be improved by 58 to 73 per cent through use of a low-emittance coating on the inside surface of the interior glass pane.
(v) The shading coefficient of the window glazing system was improved by 60 per cent with the use of heat-absorbing glass as the outside pane.

Additional Information

Final Report:
Bilgen, E. 1987. Thermal Improvement of "Vision Control" Windows. EMR Report No. T2-W3-86-6136. Ottawa, Ont.: Energy, Mines and Resources Canada.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

STUDY OF ELECTROCHROMIC MATERIALS FOR SWITCHABLE WINDOWS

Contractor
University of Moncton
Department of Physics
Moncton, N.B.
E1A 3E9

Principal Investigator
Truong Vo-Van (506) 844-4337

Background
"Optical switchable" glazing is coated with an electrochromic material which changes from transparent to opaque when electrical voltage is applied. This switchable property is achieved by first applying a coat of transparent electrical conductor to the glass, then adding an electrochromic coating and an ion storage layer. A final coat of transparent conductor completes the process. Optical switching materials and coatings are used to regulate the transmissivity of windows. The coatings may also exhibit low-emissivity.

Among inorganic materials, tungsten oxide seems to be most promising material for electrochromic windows. It is hoped that Canadian expertise in the field of switching materials will be further developed as a result of this project.

Objectives
To develop a multi-layer electrochromic switching device using inorganic tungsten oxide, and to establish the optimal conditions for film deposition

To test the performance of the multi-layer coatings

To measure optical properties and identify the best device for high-performance windows

To represent Canada at International Energy Agency meetings on Task X, Low-Emissivity and Electrochromic Glazing Materials

DSS File No.: 23283-8-6052
EMR File No.: CE7161-U5
Contract Start Date: Sep 88
Completion Date: Aug 89
Project Value: $75,900
EMR Funding: $75,900

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

MONITORING AND PERFORMANCE EVALUATION OF ATTACHED SUNSPACES

Contractor
University of Saskatchewan
Department of Mechanical Engineering
Saskatoon, Saskatchewan
S7N 0W0

Principal Investigator
Greg Schoenau (306) 966-5440

DSS File No.: 23216-6-6294/01
EMR File No.: CN7161-U3
Contract Start Date: Jan 87
Completion Date: Jul 88
Project Value: $61,996
EMR Funding: $61,996

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Attached sunspaces have become an integral and popular part of many energy-efficient homes and they are quickly gaining consumer acceptance. However, little quantitative information is available on the thermal performance of attached sunspaces in occupied houses. Field-monitored information is required to serve as a sound basis for sunspace promotion and design.

Objectives
To measure sunspace air infiltration characteristics

To monitor four sunspaces for one year, including continuous measurement of ambient sunspace and house air temperatures, solar insolation, and heating and cooling energy requirements

To evaluate the thermal performance of attached sunspaces and to assess any overheating or cooling problems

Results
Monitoring has been completed on four sunspaces which are attached to occupied residential houses. The sunspaces can be isolated from the main house by closing connecting doors. All of them differ in glazing orientation and wall insulation levels. One of the sunspaces has windows with insulating blinds between the glazings while another one has sloped sidewalls and glazing on the roof.

Each sunspace was monitored by a continuous computerized data acquisition system. Air infiltration rates were measured using tracer gas measurements. The figure shows a comparison of infiltration rates for sunspaces.

A computer program was developed to model the thermal behaviour of sunspaces and to aid in the design of energy-efficient sunspaces. The program was validated using the measured data. Year-round performance data collection has shown encouraging results, and a final analysis is now available in the form of both a final report and a shorter technical note summarizing the findings.

Additional Information

Final Report:
Schoenau, G. and A. Lumbis. Monitoring and Performance Evaluation of Attached Sunspaces. EMR Report No. T2-W7-86-6294. Ottawa, Ont.: Energy, Mines and Resources Canada.

Technical Note:
Department of Mechanical Engineering. Performance Data and Design Guidelines for Attached Sunspaces in Canada. Saskatoon, Sask.: University of Saskatchewan.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

CENTRE OF EXPERTISE FOR BASIC RESEARCH INTO ADVANCED GLAZING SYSTEMS

Contractor
University of Waterloo
Department of Mechanical Engineering
Advanced Glazing System Laboratory
Waterloo, Ontario
N2L 3G1

Principal Investigator
Harry Sullivan (519) 885-1211

DSS File No.: 23216-6-6122/01
EMR File No.: CN7161-U2
Contract Start Date: May 86
Completion Date: Jun 89
Project Value: $273,738
EMR Funding: $246,975

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by the Office of Energy Research and Development, Energy, Mines and Resources Canada

Background
Modern low-energy buildings feature larger window areas, higher levels of wall insulation and lower infiltration rates. A wide variety of high thermal-resistant glazings and components is also available. However, more complex design and evaluation methods are required for these glazing systems, and the industry requires a strong support service for their development.

Funded under a three-year contract, the Advanced Glazing System Laboratory was established as a centre of expertise at the University of Waterloo in 1986. The laboratory conducts basic research, encourages technical advancements and aids industry in product development.

The laboratory also continues to upgrade the VISION computer program, originally developed as a research tool under a previous National Research Council contract.

Objectives
To improve the VISION computer program, make it available to industry and provide user services

To upgrade the VISION program as new technologies emerge

To develop a test apparatus to accurately measure heat transfer through glazing system prototypes, and to measure the optical properties of glazings

To perform basic research in modelling and simulation of heat transfer, and to inform industry of research results and advances in high-performance window technology

Results
VISION has been enhanced and is now available to industry with limited user support. The computer program can be obtained from the Advanced Glazing System Laboratory. It is being modified to include graphical input and output routines.

An experimental test apparatus for measuring heat transfer through glazing systems has been developed and prototype glazing units are being tested. An algorithm is being developed to accurately model two-dimensional heat transfer between glazings, including the edge condition.

Laboratory operation is supported in part by the provision of consulting and research services to the glazing industry. Services include the following:

(i) Availability of the VISION program with user support
(ii) Technical input to support glazing system development
(iii) Research studies for manufacturers or research agencies
(iv) Computer studies involving VISION or specially tailored versions
(v) Experimental U-value measurement of glazing systems

Additional Information

Note: Annual reports for 1986/87 and 1987/88 are available from the Advanced Glazing System Laboratory, Department of Mechanical Engineering, University of Waterloo.

PROJECT SUMMARIES
Passive Solar

Demonstration Projects

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

DEVELOPMENT OF A PROTOTYPE RESIDENTIAL INTEGRATED MECHANICAL SYSTEM

Location
Toronto, Ontario

Proponent
Allen Associates
33 Madison Avenue
Toronto, Ontario
M5R 2S2

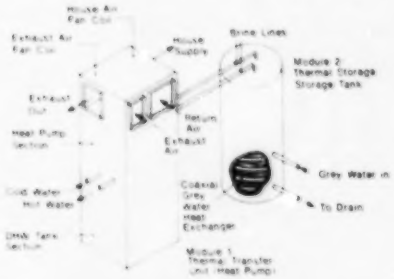
Mario Kani (416) 962-6193

Objective
To develop and test a residential prototype integrated mechanical system and to modify its design to meet commercial requirements

Description
Residential integrated mechanical systems, also called integrators, consist of a single piece of equipment which combines space heating, hot water heating, an air-to-air heat exchanger, a ventilation system and thermal storage.

A laboratory prototype test unit was developed under a previous National Research Council contract. Field testing of the prototype was performed at the Ecology House in Toronto.

The integrator incorporates a liquid-to-liquid heat pump connected to two thermal storage tanks, one for ice and one for hot water. The ice thermal storage tank contains a brine-to-water/ice heat exchanger. Cooling is supplied by circulating the brine through a cooling coil. The system provides heat by passing recirculated house air through a hot water fan-coil for forced-air distribution. Waste heat generated in the house is delivered to the ice thermal storage tank. The heat pump extracts this waste heat from the ice storage tank to replenish the thermal storage tank. Cooling is maintained by the heat pump throughout the process. Ventilation operates either at low or high speed, and can be controlled automatically or manually.



Results
The laboratory prototype unit was redesigned to include increased thermal storage, and five prototype units were produced. One of the units is undergoing rigourous laboratory tests at Ontario Hydro. Following testing, it will be installed at the Ontario Solar Demonstration House.

From the initial performance results, the integrator is predicted to generate an output of 6 kW, and it should save 4,000 to 10,000 kW·h annually, compared to traditional electrical and mechanical ventilation systems.

EMR File No.: CN7162-A1
Contract Start Date: Dec 85
Completion Date: Dec 88
Project Value: $117,713
EMR Funding: $89,999

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario,
K1A 0E4

Funding for this project was provided by Energy, Mines and Resources Canada under the Special Projects Program

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

INSULATING CURTAIN FOR GREENHOUSES

Location
Delacour, Alberta
Located 30 km northeast
of downtown Calgary

Proponent
Appropriate Technology
Energy Company
1465 Russell Road N.E.
Calgary, Alberta
T2E 5N2

Robert E. Leckie (403) 276-1869

Objectives
To determine the cost savings derived from the application of an insulating curtain, and to define the technical capacity of the curtain under continuous use

Description
Previous research and development work aimed at single-paned greenhouses suggests that the installation of insulating curtains could generate system paybacks of approximately three years. These favorable economics imply that if insulating curtains prove technically feasible, fresh vegetables could be produced in sufficient quantities locally.

Although Mayo, Yukon was originally proposed as the project site, southern Canada is a more suitable location to demonstrate the technology.

Results
An insulating curtain with a width of over 100 ft and a length per side of approximately 30 ft was installed at a greenhouse in Delacour. The system has not achieved technical expectations. Problems have arisen because the curtain width is too great. Because the system is unable to roll and unroll the curtain evenly, it will be damaged by repetitive use.

The project has been terminated.

EMR File No.: CN7909-4-2
Start Date: Jul 87
Completion Date: Oct 88
Project Value: $36,800
EMR Funding: $18,400

For further information, write to:
EMR - Alberta Regional Office
9700 Jasper Avenue
6th Floor
Edmonton, Alberta
T5J 4C3

Funding for this project was provided by Energy, Mines and Resources Canada under the Enerdemo Program

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

HIGH THERMAL PERFORMANCE WINDOWS IN THE FLAIR HOMES ENERGY DEMONSTRATION PROJECT

Location
Flair Homes Housing Project
Winnipeg, Manitoba

Proponent
Flair Homes
94 Roslyn Road
Winnipeg, Manitoba
R3L 0G6

Bruce Maybank (204) 477-1217

EMR File No.: CN7907-4-3
Start Date: Jan 88
Completion Date: Mar 89
Project Value: $150,000
EMR Funding: $150,000

For further information, write to:
EMR - Manitoba Regional Office
213 Notre Dame Avenue
Room 1003
Winnipeg, Manitoba
R3B 1N3

Funding for this project was provided by Energy, Mines and Resources Canada under the Enerdemo Program

Objectives
To field demonstrate and evaluate high thermal performance windows in the Flair Homes project

To expand the number and types of building envelope and mechanical system options currently included in the project

Description
In an earlier phase of this project, 20 houses were built which integrate low energy construction and various mechanical systems with an emphasis on ventilation. These houses are presently occupied and are now being monitored.

Phase II of this project involves the construction of three new houses which feature high thermal performance windows and other low energy technologies. A fourth unoccupied test house will also be built. The purpose of this project is to obtain extensive long-term field data on high thermal performance windows and their effect on energy consumption and occupant comfort.

All 24 houses will be extensively monitored until the spring of 1989. The results will be disseminated to the Canadian home building industries.

Results
The three houses which will be occupied are built and preliminary monitoring is underway. Samples of the high thermal performance windows are currently undergoing more detailed laboratory testing. Installed samples will be removed from the houses after several years and will be tested again for performance degradation.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

ADVANCED HOUSE DEMONSTRATION PROJECT IN ONTARIO

Location
Toronto, Ontario

Proponent
Fram Building Group
220 Humberline Drive
Rexdale, Ontario
M9W 5Y4

L. Ciccotelli (416) 675-9179

EMR File No.: CN7906-4-7
Start Date: Sep 87
Completion Date: Mar 89
Project Value: $575,500
EMR Funding: $85,000

For further information, write to:
EMR - Ontario Regional Office
55 St. Clair Avenue East
Room 606
Toronto, Ontario
M4T 1M2

Funding for this project was provided by Ontario Hydro, the Ontario Ministry of Energy and by Energy, Mines and Resources Canada under the Enerdemo Program

Objectives
To design, build, monitor and promote a Canadian energy efficient house which features numerous energy efficient measures and technologies available today or expected to be commercially ready within three to five years

To showcase the completed house to builders and the public for a one-year period

Description
There have been many advances in low-energy building design, mechanical systems, appliances and components since the introduction of the Super Energy Efficient Home Program (commonly known as R-2000). Although some features have been incorporated into individual R-2000 homes, a low-energy house which incorporates innovative "second generation" products would serve to inform the industry as well as increase public awareness of passive solar technologies.

An advanced low-energy house could potentially utilize only one-third of the total energy requirements of a conventional home. Design features include sunspaces to demonstrate significant passive solar gains; high thermal performance windows; advanced mechanical systems with thermal storage capacity; energy efficient lights and appliances; electronic energy management technology; improved envelope construction; air quality which meets or exceeds CSA draft standard F-326; and improved fireplace technology.

Results
The house is now under construction in Brampton, Ontario and should be open for public viewing by February, 1989.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

PASSIVE SOLAR TECHNOLOGY INFORMATION SESSIONS

Locations
Various cities in Quebec

Proponent
Institut Grace
4222 St-Denis Street
Montreal, Quebec
H2J 2K8

Christian Ouellet (514) 843-6417

Objectives
To teach simple and inexpensive passive solar techniques for small and medium-sized residential buildings to construction professionals

To conduct 12 training sessions regarding passive solar technologies in 10 Quebec cities

To conduct four intensive training sessions in Montreal and Quebec City

To produce a guide about passive solar technologies to be distributed to conference participants

Description
Passive solar instruction sessions for members of the various provincial builders associations in Quebec will aid in the promotion of this technology. Construction and professional associations will benefit from a series of training sessions about passive solar technologies. Twelve sessions are scheduled in 10 Quebec cities, and two intensive sessions each are planned in Montreal and Quebec City.

Results
Training sessions have been conducted in Montreal, Quebec City, Chicoutimi, Rimouski, Sherbrooke and Joliette. Lectures about passive solar design features were presented by Institut Grace personnel.

EMR File No.: CE7941-12
Start Date: Jan 87
Completion Date: Jan 88
Project Value: $89,517
EMR Funding: $24,121

For further information, write to:
EMR - Quebec Regional Office
200 René-Lévesque Blvd West
West Tower, Room 501
Montreal, Quebec
H2Z 1X4

Funding for this project was provided by the province of Quebec and by Energy, Mines and Resources Canada

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

MODEL HOME WHICH USES PASSIVE SOLAR CONCEPTS

Location
Montreal, Quebec

Proponent
Institut Grace
4222 St-Denis Street
Montreal, Quebec
H2J 2K8

Christian Ouellet (514) 843-6417

Objectives
To construct a model passive solar house with heating costs roughly equal to those of an R-2000 home

To design the model home so it can be replicated five times in the same residential development

Description
Houses with integrated passive solar concepts have a proven capacity to reduce overall heating costs. However, increased public awareness of these useful technologies is required to promote their application in more Canadian homes.

A house which incorporates windows with direct solar gains will be built using the Géminé System, which involves the recuperation and storage of solar gains in a concrete slab located beneath the house.

Institut Grace will provide technical support and supervise the monitoring of the model home.

Results
The house should be completed by the end of spring, 1989. Its performance will be monitored for one year.

EMR File No.: CN7905-4-10
Start Date: Mar 87
Completion Date: Jul 89
Project Value: $130,928
EMR Funding: $18,676

For further information, write to:
EMR - Quebec Regional Office
200 René-Lévesque Blvd West
West Tower, Room 501
Montreal, Quebec
H2Z 1X4

Funding for this project was provided by the province of Quebec and by Energy, Mines and Resources Canada

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

DEMONSTRATION OF A SOLAR LIGHT PIPE SYSTEM

Location
Victoria Park Place
North York, Toronto

Proponent
Konvey Construction Co. Ltd.
P.O. Box 520
Milliken, Ontario
L0H 1K0

John R. Hawley (416) 298-9106

EMR File No.: CE7152-K1
Start Date: Jul 85
Completion Date: Dec 87
Project Value: $198,641
EMR Funding: $148,981

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by Energy, Mines and Resources Canada under the Special Projects Program

Objective
To field test and demonstrate the possible benefits of the patented solar light pipe as an alternative to electric lighting and to increase public awareness of this technology

Description
TIR Systems Ltd. of Vancouver conceived and developed the solar light pipe illumination system, which was patented under the trade mark LIGHTPIPE^{tm}. Designed and installed by TIR Systems for Konvey Construction, a prototype solar light pipe system was commissioned and presently operates on the top floor of a Toronto office building. The prototype was first tested at the National Research Council's Low Temperature Laboratory and at the B.C. Research Facility before it was demonstrated at Victoria Park Place.

A light pipe is a duct system which relies on the principle of total internal reflection, the same principle used in fibre optics. Each pipe uses a hollow rectangular tube lined with sheet plastic with a prismatic shaped surface finish to transmit light along its length. A diffuser on one side of the pipe allows light rays to escape. The Toronto system incorporates 12 light pipes. Eight computer-controlled tracking heliostats are mounted on the roof in a glass-enclosed structure and concentrate and direct sunlight into eight separate light pipes. Each of the eight light pipes uses two metal halide luminaries as a backup/enhancer, while the remaining four isolated light pipes rely on two metal halide luminaries as the sole source of light. These four separate light pipes serve as an experimental control for comparison with the solar system.

Results
The system was monitored for its effective use of sunlight for 30 days.

The rooftop glass room which houses the heliostats requires additional cooling in order to maintain acceptable temperatures on hot, sunny days. As well, a five-ton air conditioning unit was installed by Konvey to prevent elevated temperatures from adversely affecting the computer components which control the tracking heliostats and the curvature of the ceiling mirrors.

The lighting power required by the top floor offices was reduced by an average of 40 to 50 per cent, which is consistent with the amount of intense sunlight available in Toronto. When sunlight is available, 6.4 kW of electric lighting load are eliminated.

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

HYBRID SOLAR SYSTEMS IN URBAN HOUSING

Location
Montreal, Quebec

Proponent
Les Constructions Solden Inc.
9334 2nd Avenue
St-Michel, Montreal, Quebec
H1Z 2T1

Denis Martineau (514) 389-2533

Objective
To demonstrate the energy savings potential of new hybrid active/passive solar systems for urban housing

Description
Hybrid active and passive solar systems have the potential to significantly reduce overall space heating costs. Three semi-detached single-family homes were equipped with hybrid solar heating systems to demonstrate this concept.

The systems comprise collection and storage mechanisms, and a natural ventilation system that distributes heat and prevents overheating. Encased "caisson-type" windows, a mass wall, and ventilation ducts have also been contained in the homes. The windows provide natural ventilation, direct or indirect solar gains as desired, and good thermal insulation to reduce heat loss. The inside mass wall stores and distributes excess heat. Ventilation ducts complete distribution by channelling heat from the windows to the mass wall.

It is predicted that the three houses will combine to generate a savings of 43 GJ.

Results
Monitoring will extend over a one-year period. Measurements will be taken in the short-term to determine the heat loss coefficient of the building, to test for air leakage and to evaluate the performance of major system components. Temperature, electrical consumption and solar radiation will be monitored.

EMR File No.: CN7908-4-2
Start Date: Mar 86
Completion Date: Mar 88
Project Value: $34,140
EMR Funding: $24,880

For further information, write to:
EMR - Quebec Regional Office
200 René-Lévesque Blvd West
West Tower, Room 501
Montreal, Quebec
H2Z 1X4

Funding for this project was provided by Energy, Mines and Resources Canada under the Enerdemo Program

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

SOLAR GREENHOUSE CONSTRUCTION COURSE: INSTRUCTORS SEMINAR

Location
Dartmouth, Nova Scotia

Proponent
Solar Nova Scotia
R.R. #1, McGrath Cove
Halifax County, Nova Scotia
B0J 3L0

Don Roscoe (902) 852-3789

Objectives
To conduct a weekend training course to prepare instructors for a new course aimed at the general public

To disseminate up-to-date technical information on passive solar design and construction within the province

Description
In 1983, Solar Nova Scotia developed a course which deals with the design and construction of passive solar additions and greenhouses. The Solar Greenhouse Course was offered from 50 to 70 times around the province, and attracted between 800 and 1,000 participants. The course focuses on the fundamentals of passive solar energy, site planning, design, construction theory, and special passive solar construction techniques.

With a view to establishing the course as less instructor-dependent, Solar Nova Scotia updated and expanded it in 1986. The course format was altered from a slide and tape presentation to a videotape cassette.

The main barrier to widespread presentation of this course is the lack of qualified instructors, particularly in rural areas where interest in passive solar technologies is high.

Results
Instructor trainees were recruited from the group of instructors who attended a similar meeting in 1983 and from a list provided by high school vocational arts institutions around the province. A weekend instructor training course was held in Dartmouth, Nova Scotia in the fall of 1987. Course attendance was limited to 20 people from around the province.

The course provided the students with the confidence and information required to design and build an attached solar structure. As a result, many participants included passive solar features in their new homes.

Additional Information

Course Manual:
Kassner, R., J. Marshall and D. Roscoe. 1986. Solar Greenhouse Course Manual. McGrath Cove: Solar Nova Scotia.

Project Summary:
Solar Greenhouse Course. Apr., 1987. Nova Scotia Department of Mines and Energy.

Video:
Solar Nova Scotia. A Course on Solar Greenhouses, Lessons 1,2,3 and 4.

EMR File No.: CN7903-4-1
Start Date: Mar 87
Completion Date: Dec 88
Project Value: $4,000
EMR Funding: $3,200

For further information, write to:
EMR - Nova Scotia Regional Office
Bank of Montreal Tower, Suite 503
5151 George Street
Halifax, N.S.
B3J 1M5

Funding for this project was provided by the province of Nova Scotia and by Energy, Mines and Resources Canada

RENEWABLE ENERGY PROJECT SUMMARY
Passive Solar

SOLAR CLIMATE CONTROL SYSTEM

Location
Valleyfield, Quebec

Proponent
Thermactive Inc.
167 D. Lebeau
Ste-Anne-de-Bellevue, Quebec
H9X 3L2

Richard Nelson (514) 636-9945

EMR File No.: CE7162-T1
Start Date: Mar 85
Completion Date: Jul 87
Project Value: $132,000
EMR Funding: $99,000

For further information, write to:
Energy, Mines and Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4

Funding for this project was provided by Energy, Mines and Resources Canada under the Special Projects Program

Objective
To provide solar heat for space heating or cooling distribution for climate control

Description
Greenhouses and other large spaces enclosed with transparent material are susceptible to excessive heat loss in winter and overheating in summer. Thermactive has developed a glazing system that addresses the problem of climate control in transparent material enclosed structures.

The Thermactive glazing system consists of a double-glazed transparent enclosure made of plastic. The system's thermal resistance and solar transmittance can be changed by filling the enclosure cavity with transparent foam. During the heating season, the cavity filled with foam can reduce heat loss. During the cooling season, the foam can reduce overheating of the interior by decreasing the transmittance of solar energy as well as heat conduction. To provide additional cooling, water can be trickled down over the interior glazing.

Thermactive installed 280 m² of their glazing system on the south-facing roof of a greenhouse. The enclosure cavity is approximately 40 cm thick. The insulating foam that fills the cavity is produced from a soap solution. A centrifugal pump delivers the solution from a storage tank to a screen which is fitted to the edge of the window cavity. A fan blows air onto the screen causing soap bubbles to form and fill the cavity. To remove the foam, the fan blows existing bubbles back to the storage tank through a return pipe. A separate holding tank located under the greenhouse stores the cooling water.

Results
Termination of the Special Projects Program did not allow the performance monitoring of the system to be carried out. However, the system was reported to be working adequately. The company reports that in addition to controlling solar gain, the climate control system substantially reduces winter heat loss.

Passive Solar Index

A-B-C

Advanced Glazing System Laboratory
at University of Waterloo 46

Aerogels
for high-performance windows 21

Building-Integrated Hybrid Systems
computer model 42
demonstration houses 56

Calibrated Modelling Technique
for solar buildings 28

Commercial buildings
design seminars 22

Computer software
BLAST 28
Computer Aided Window Frame Design 25
ENERPASS, improvements to 26
FRAME 24,25
to design building-integrated systems 42
VISION 46

Concepts, passive solar
first generation 16
second-generation demonstration house 16,52

Controllers
for solar buildings 13,14

D-E-F

Demonstration homes
active/passive hybrid 56
in ONT 52
in QUE 54

Diamond Window Assembly
performance evaluation of 20

Edge Spacers for sealed glazing units
effect on window heat loss 24
insulated foam spacer 23
for vacuum units 36

Electric heating glass 40

Electrochromic coatings
organic polymer materials 29,30
test lab for 15
tungsten oxide 44

Flair Homes
high-performance window demonstration 51

Frames, window
effect of components on thermal performance 24
computer analysis of thermal performance 25

G-H-I

Gas-fill technology
development of a vacuum chamber filling procedure 37

Geminé System
concrete floor thermal storage 54

Greenhouses
foam-filled glazing system 58
insulating curtains 50

Gypsum wallboard, with phase-change materials 19,35

Heat pumps with
integrated mechanical systems 17

High-performance windows
Advanced Glazing System Laboratory 46
aerogels 21
effect of frame design on 24
electric contacts 40
evacuated glazing units 36
gas-filled units 37
with insulated spacers 23
marketability study 18

Hybrid systems, passive solar
active charge/passive discharge
computer model 42
demonstration houses 56

Insulating curtains
for greenhouses 50
for sloped glazing 20
roller shade 31

Integrated mechanical systems 17,26 49,51,52

L-M-N

Light pipe system
for multi-storey use 41
Victoria Park demonstration project 55

Low-emissivity coated glazings 31,34, 39,43
deposition techniques for 40
fluorine-doped tin oxide 39,40
heat loss reduction 24
on laminar air flow windows 27
with low conductive gas-fill 23,37
measurement of optical properties 15
preparation by spray pyrolysis 39
test lab at Acadia University 15

Monitoring
using calibrated model 28
development of low-level program 32
Level B fact sheets 33
Level B monitoring 32,33

P-R-S

Passive solar information sessions
design seminar in Manitoba 22
in Quebec 53

Phase-change materials
in gypsum wallboard 19,35

Sunspaces, attached
design and construction course 57
insulated, vented double glazing systems for 20

monitoring and performance evaluation of 45

T

Technology transfer
design seminars 22
development of technology transfer plan 16

Testing Laboratory
for advanced glazing systems 46
for low-emissivity and electrochromic coatings 15

Thermal performance
of advanced glazings 46
of gypsum wallboard with PCM thermal storage 35
labelling program for windows 34
of laminar air flow windows 27
of mass wall hybrid systems 56
of passive solar designs 26,32
of roller shade windows 31
of solar heated concrete floor 54
of Vision Control windows 43
of window frame designs 24

Thermal storage
concrete floor slabs 54
gypsum wallboard with phase change materials 19,35
with integrated mechanical systems 17
in mass walls 56

V-W

Venetian blinds
inside"Vision Control" windows 43

Ventilation window 27

"Vision Control" window system
thermal improvement of 43

Window energy performance
field test and monitoring 51
labelling program development 34

Window insulation
curtain for greenhouses 50
foam-filled glazing 58
in sloped glazing assembly 20
in vertical glazing assembly 31

Window Testing Laboratory
at National Research Council, test results 20,39

CUT HERE AND MAIL TO THE ADDRESS SHOWN BELOW.

Order Form For The Renewable Energy Projects Digest

Name _____

Business/Organization _____

Address _____

City _____ Prov. _____ Postal Code _____

I wish to receive the following publications which comprise the Renewable Energy Projects Digest (please mark an "X" in the space provided):

___ All six technologies

___ Active Solar

___ Passive Solar

___ Photovoltaics

___ Small/Low Head Hydro

___ Wind Energy

___ Earth Energy (Geothermal and Heat Pumps)

___ Projects Digest Overview

Please provide the publication(s) in the following languages:

___ English

___ French

___ Both languages

Please return this completed form to the following address:

Renewable Energy Technologies
Energy, Mines and Resources Canada
6th Floor
460 O'Connor Street
Ottawa, Ontario
K1A 0E4